ENVIRONMENTAL QUARTERLY

January • 1961

The Pioneer Space Age Publication of Environmental Simulation, Testing, Engineering and Equipment Manufacturing

INDEPENDENTLY PUBLISHED

Volume 7 • Number 1

181
3868
885-2

ANOTHER LING FIRST! NEW 5000 LB. SHAKER —PROVIDES BUILT-IN PIGGY-BACK CHAMBER CAPABILITY

Ling offers you another design first with its new Model 300 Shaker. This new 5,000-pound-force shaker features Ling's unique closed-loop water-cooling system, a hermetically sealed system which is specifically designed to eliminate coolant contamination of an environmental chamber. Without any special shaker accessories, it operates with a piggy-back chamber, permitting testing to unlimited altitudes and humidity, and at temperatures from −100° to +300°F. The specially designed lightweight armature weighs only 41.5 lbs. Ling's unique low-voltage armature and field design eliminates corona problems when operating at altitudes, and the temperature range can be readily expanded above 300°F with the addition of an external thermal barrier. For details on Model 300, write Department EQ-161 at the address below.

LING-TEMCO ELECTRONICS, INC.

LING ELECTRONICS DIVISION

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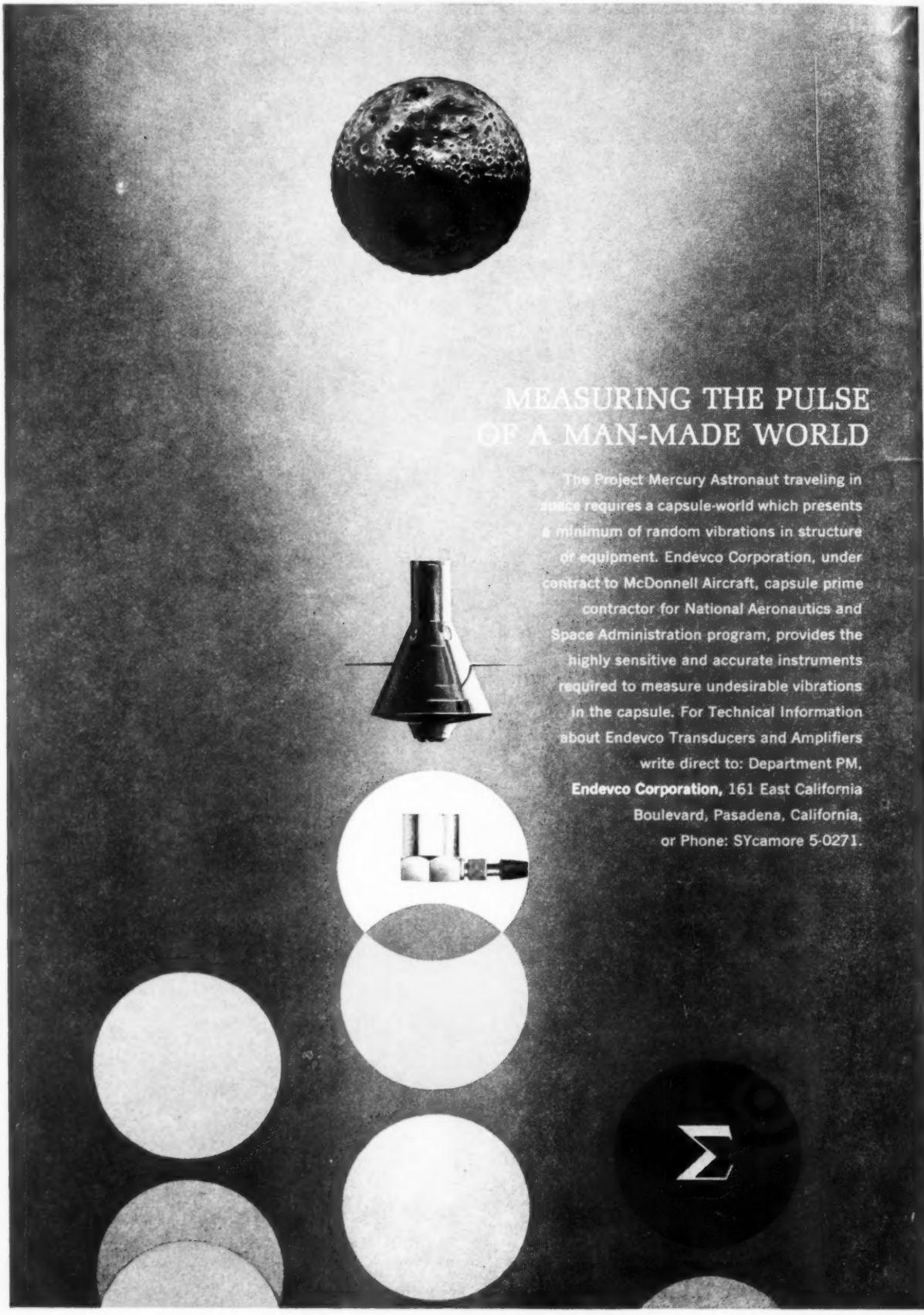
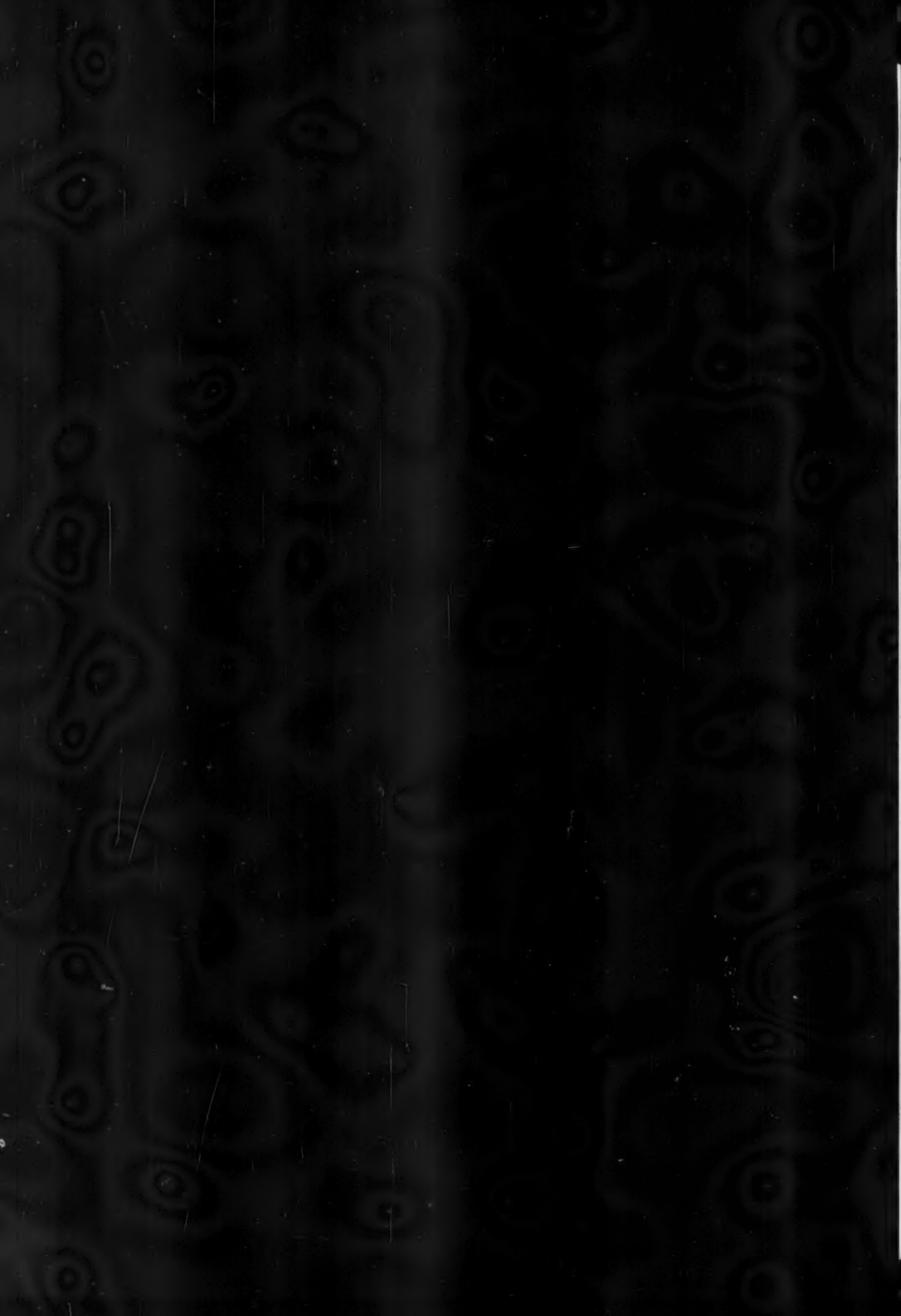
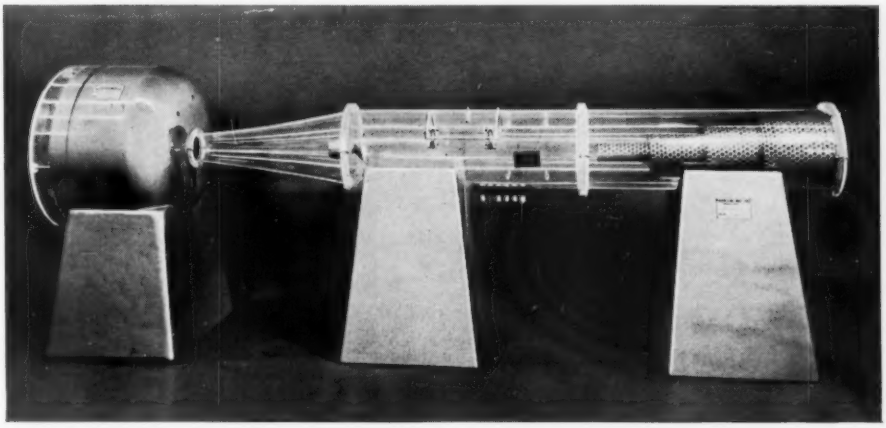

MEASURING THE PULSE
OF A MAN-MADE WORLD
The Project Mercury Astronaut traveling in space requires a capsule-world which presents a minimum of random vibrations in structure or equipment. Endevco Corporation, under contract to McDonnell Aircraft, capsule prime contractor for National Aeronautics and Space Administration program, provides the highly sensitive and accurate instruments required to measure undesirable vibrations in the capsule. For Technical Information about Endevco Transducers and Amplifiers write direct to: Department PM, Endevco Corporation, 161 East California Boulevard, Pasadena, California, or Phone: SYcamore 5-0271.



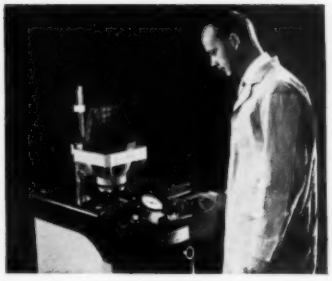
Use-proven RESEARCH TOOLS from AVCO

ACOUSTIC NOISE EQUIPMENT

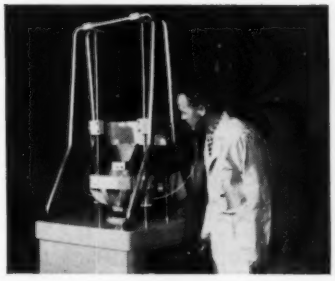
ACOUSTIC NOISE GENERATOR AG-012 simulates the random noise of rocket engine firing. Other Avco noise test systems available in a variety of configurations to meet specialized requirements. Systems available with random noise ouputs of 163, 150, 140 and 120 db. Complete capability and experience available to build custom systems for individual requirements through the utilization of standardized components.



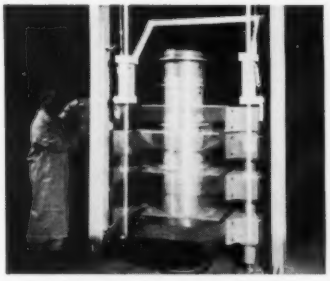
SHOCK TEST EQUIPMENT



AVCO's SM-005, a compact, pneumatically controlled shock test machine for component testing. Provides sawtooth, triangular and half-sine pulses to 3000 g's force, extra capability to meet new pulse needs. Recycles automatically. 30-lb. capacity (50-lb. with special impact devices). High degree of repeatability.

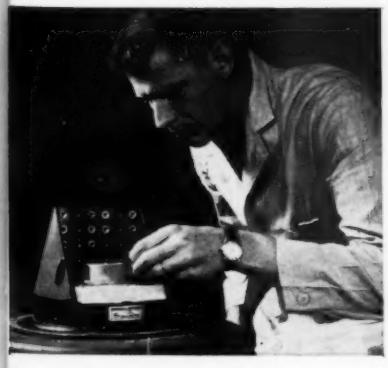


SM-010 SHOCK MACHINE. Widest variety of pulse shapes available for faster environmental tests with unmatched repeatability. 100-lb. capacity. Exclusive design rebound brake a standard feature. Provides shock pulses up to 3000 g's for transistor testing. Patented carriage design permits controlled sawtooth pulses.



SM-030 SHOCK MACHINE. This precision-engineered shock machine is particularly useful in handling specimen loads up to 500 pounds for testing complete systems for half-sine and sawtooth pulses. The SM-030 incorporates many features of smaller machines, including high degree of repeatability.

ENVIRONMENTAL TEST FIXTURES



TF-006 is designed for use as an integral part of such environmental test equipment as vibration exciters, shock machines and centrifuges. Permits simultaneous testing of components in each of three mutually perpendicular planes. Virtually resonance-free up to 2000 cps.

Represented by local agents throughout the United States and the world, these products are fully use-proven in research and development laboratories across the nation.

For more information write: Industrial Products Subdivision, Research and Advanced Development Division, Avco Corporation, Wilmington, Massachusetts.

AVCO
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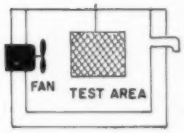
division

here's 4 ways CARDOX® CO_2

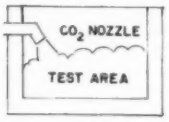
can help you achieve versatile... fast... low cost BELOW 0° F. ENVIRONMENTAL TESTING

1 dry ice chamber



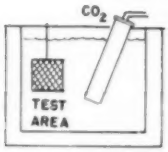
Simple, easy, inexpensive. A fan blowing over a wire basket full of crushed dry ice will reduce chamber temperatures from 0 to —70°F. A quick, low cost method for making occasional or isolated cold tests.

2 direct discharge of liquid CO_2



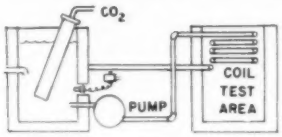
Easiest, most efficient method for consistent, cold testing in production operations. Bulk liquid carbon dioxide is discharged directly into the test chamber. You get controlled test conditions from 0 to —100°F. in 60 seconds or less. Best of all, one CO_2 storage tank can serve a battery of test chambers.

3 immersion tank method



For low cost production-line cold testing. Crushed dry ice or bulk liquid CO_2 is injected into an acetone, methanol or trichlorethylene base solution. Items to be tested are immersed in the slurry which has a temperature of minus 109°F. An ideal method of making cold "shock" tests.

4 indirect cooling method



Bulk liquid CO_2 is discharged directly into refrigerant line or surge tank containing acetone, methanol or trichlorethylene type solution. Refrigerant is then pumped thru test chamber to reduce temperature by means of coil-type heat exchanger. Major advantage—no CO_2 atmosphere in test chamber . . . an important factor where this condition is not desirable.

This exclusive feature can save you up to 15%
CARDOX® PATENTED RE-CYCLING SYSTEM
keeps Liquid CO_2 COLDER . . . minimizes vapor loss

Low pressure liquid Carbon Dioxide storage tanks are located some distance from the point of use. Heat in the piping may vaporize a part of the liquid CO_2 so that vapor as well as liquid CO_2 arrives at the nozzle. This is undesirable for several reasons.

1. The vapor has reduced refrigerating effect and results in a loss of CO_2.
2. The vapor causes intermittent discharge; discharge rate and control is affected.
3. Starting may be delayed as large amounts of vapor must be discharged before pipe cools sufficiently to eliminate creation of vapor.
4. Vapor discharge can interfere with temperature control accuracy.

The exclusive Cardox Re-Cycling System eliminates these disadvantages.

Float valve just prior to the nozzle separates vapor from the liquid CO_2. A vapor pump connected to a return line pumps the vapor back to the storage tanks.

The new Cardox Re-Cycling System means greater efficiency, control and economy for users of bulk liquid CO_2 systems.

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To receive your copy of a new illustrated booklet fully describing the various methods of CO_2 testing in use today, mail this coupon attached to your letterhead to:

CARDOX
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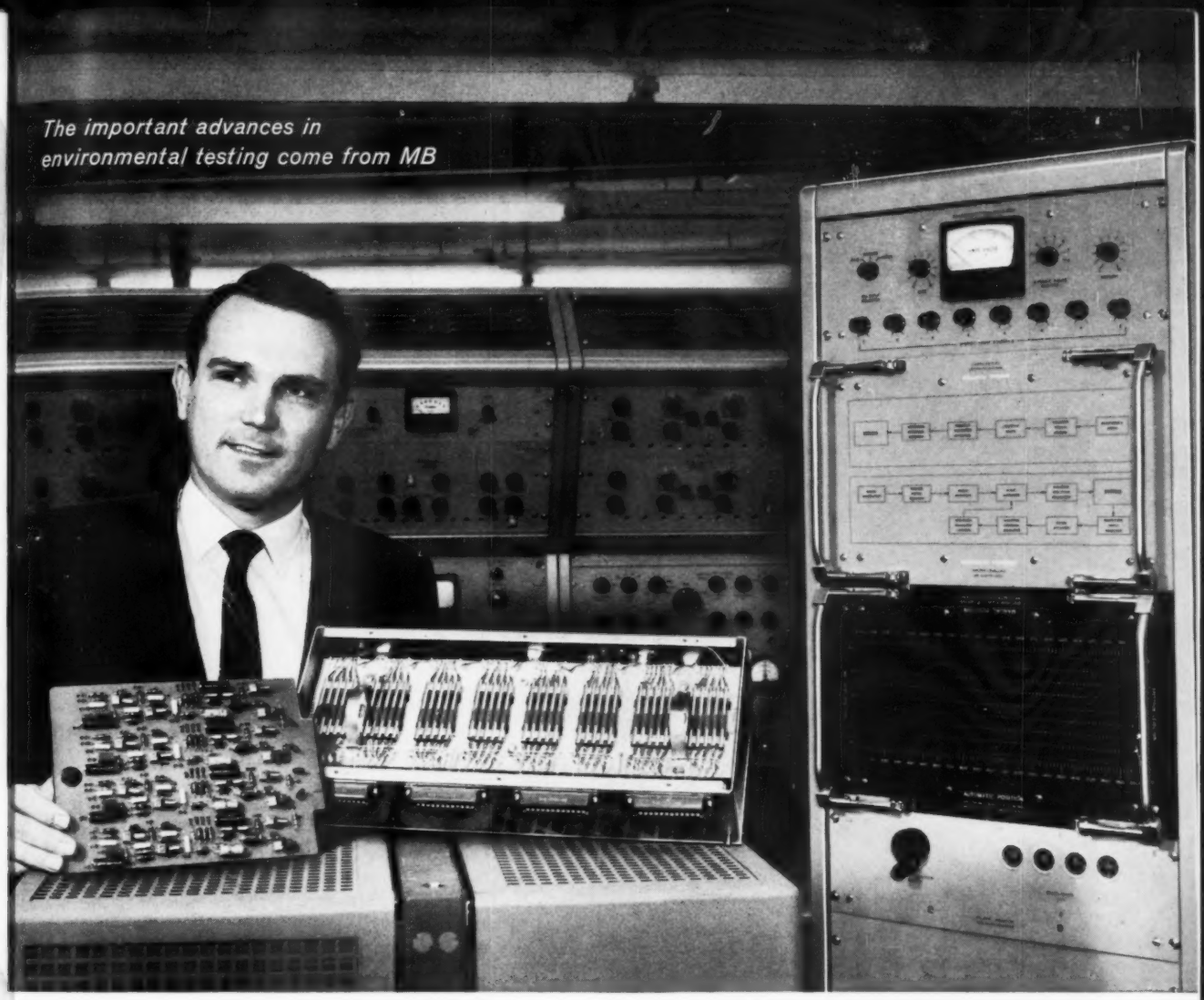
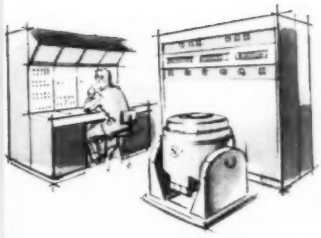
CHEMETRON

CARDOX® PRODUCTS: Carbon Dioxide Fire Extinguishing Systems, Trucks and Foam Fire Equipment . . . Liquid Carbon Dioxide . . . Carbonic Gas . . . Dry Ice

The important advances in environmental testing come from MB



NEW MB automatic spectrum equalizer to revolutionize random vibration testing



Heart of the MB automatic equalization system is the multi-channel transistorized amplifier which provides amplitude control. The plug-in printed circuit assembly shown above contains four of these channels. Frequency control is provided by the 80-channel filter assembly in the compact metal box.

CONSTITUTING a major breakthrough in applied electronics, MB's new *automatic* spectrum equalizer now means not only more accurate vibration testing . . . but tremendous savings as well in test time and money for missile and aircraft manufacturers.

The reason: set-up time has been completely eliminated. Using solid state magnetostrictive filters with correct phase properties plus servo systems on each of eighty channels in the 15 to 2000 cps spectrum, vibration shaker systems can be completely equalized within 5 seconds.

Savings in time and labor over previous equalization methods can easily mean thousands of dollars per missile tested. Still another advantage is the greatly increased accuracy of accumulated test data. The spectrum is continuously monitored in narrow bandpass channels and compensation automatically made *during* test run.

Automatic spectrum equalization is another of MB's important and continuing contributions in the field of environmental testing.

MB ELECTRONICS

A DIVISION OF TEXTRON ELECTRONICS, INC., 1057 State Street, New Haven 11, Conn.

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Environmental Quarterly

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Quarterly welcomes competent expressions of opinion, but statements in its pages do not necessarily reflect its views. Right is reserved to extract portions of letters and other material submitted for publication. Correspondents must be fully identified, but names will not be published if such a request is made.

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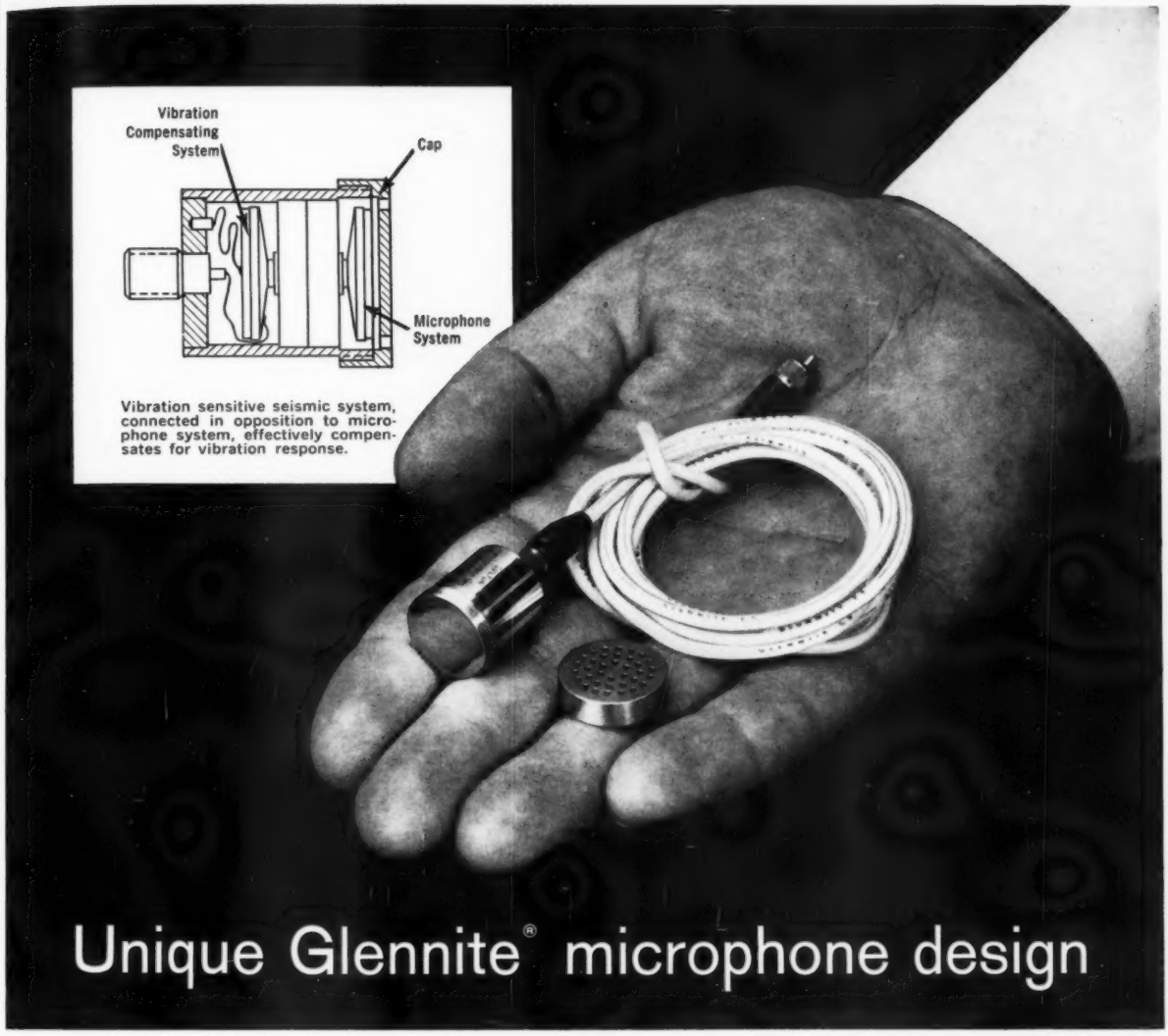

Vibration Compensating System
Cap
Microphone System
Vibration sensitive seismic system, connected in opposition to microphone system, effectively compensates for vibration response.

Unique Glennite® microphone design

...cancels out vibration!

Gulton engineers use a unique vibration compensating design in this Glennite P-420M6 microphone resulting in maximum accuracy and reliability of high intensity sound measurements.

By the addition of a vibration sensitive seismic system, electrically connected in opposition to the microphone system, response of the microphone to vibration is virtually eliminated.

Output per "g" of vibration corresponds to less than 80 db sound pressure level (SPL)—permitting microphone to maintain a high signal to noise ratio in high vibration environments.

The P-420M6 incorporating the piezoelectric seismic systems is only ⅝" in diameter, has wide dynamic range and excellent linearity. It is designed to operate in a missile environment with a ± .5 db response from −65° to +250°F.

For complete details and specifications, write Instrumentation Division, Gulton Industries, Inc.

SPECIFICATIONS

SPL Sensitivity (minimum):	0.5 mv minimum at 110 db (referred to .0002 dyne/cm²)
Range:	110 to 190 db SPL
Linearity:	Within ± 0.5 db of measured SPL over range indicated
Frequency Response:	10 cps to 3 KC ± 2 db 3 KC to 10 KC ± 3 db (parallel incidence)
Vibration Sensitivity Axial:	Equivalent to 80 db SPL at 1 g rms vibration
Temperature Range:	−65°F to +250°F, less than ± 1 db change from room ambient sensitivity

INSTRUMENTATION DIVISION

Gulton Industries, Inc.

Metuchen, New Jersey

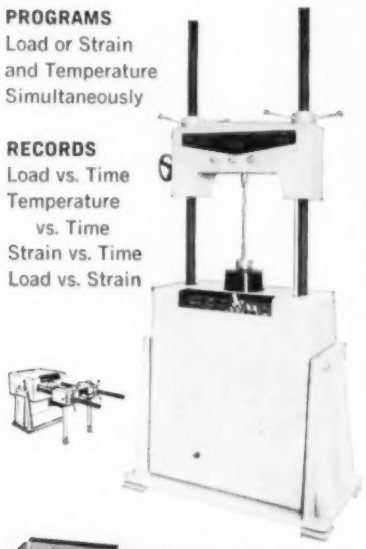
In Canada: Titania Electric Corp. of Canada, Ltd., Gananoque, Ont.

A thermal-dynamic

MATERIALS TESTING SYSTEM

PROGRAMS
Load or Strain
and Temperature
Simultaneously

RECORDS
Load vs. Time
Temperature
vs. Time
Strain vs. Time
Load vs. Strain



MODEL SHOWN
Loading Capacity: ± 10,000 lbs.
Loading Rate: ± 5,000 lbs./second
Ram: Hydraulic actuated, 8" stroke
Heating Power Capacity: Up to 130 KVA

Take the high response characteristics of electro-hydraulic servo valves and loading mechanisms, add the convenience of pencil-line program plotting, apply the precision of electronic load and temperature control and recording techniques, and you have the basis of this new testing system designed with just one thought in mind — to advance the art of materials testing.

RI RESEARCH INCORPORATED

Post Scripts

Over There

The evidence mounts of increasing interest in The Environment throughout the world. In this issue's "Around the Environs" is a first report in the United States of the activities of the British Society of Environmental Engineers.

Recently, the Society of Electronic Engineers, of India, forwarded copies of its excellent magazine, *Electro Technology*, with material on environmental testing by Col. B. M. Chakravarti, director of the Electronics Research & Development Establishment, Bangalore, and a colleague, P. S. K. Prasad.

Zeroing-In Abroad

An unusual report on the need for and use of environmental equipment abroad comes from Cincinnati Sub-Zero Products, of Cincinnati, Ohio. This company, which undertook to harness one of nature's most familiar but little understood elements—temperature, especially cold—more than 20 years ago, conducts a thriving overseas operation.

The avalanche of stamps in the accompanying illustration is from Cincinnati Sub-Zero's collection of inquiries from Kuwait to Tasmania and from Alaska to South Africa, proving, among other things, that even the frozen north may not be cold enough for some purposes.

A First-Hand Account

Let Robert J. Jacobson, president of the firm, tell the story:

"Improved and radically different manufacturing processes effected during World War II gave impetus to the refinement of refrigerating techniques, and the rush for outer space and the enormous appropriations for missiles and rockets made research in temperature technology imperative.

"Once the full scope of refrigeration was realized, refrigerating techniques improved. Equipment became available, and even the smallest nations began requesting information on chilling units and processes. Companies manufacturing this type of equipment suddenly found themselves not only with a new market, but also with having to establish an educational program regarding its use."

With expendable refrigerants unavailable in the more remote corners of the world, mechanical refrigeration has had a leading role, according to Mr. Jacobson. Only once, he adds, has Cincinnati Sub-Zero not been able to fill a request from its standard line of equipment. The request was for a chiller for an African safari.

World-Wide Cold

Other requests? An installation in the rugged mountains of Uganda, for artificial insemination. Expansion fit and chilling of aluminum rivets for a South American airplane manufacturer. Miniature precision bearing assembly and stabilization in Switzerland. Medical research and storage of human parts in India.

"One of our most unusual inquiries came from an embalmer in Africa," Mr. Jacobson relates. "He was the only mortician in a thousand-mile radius."

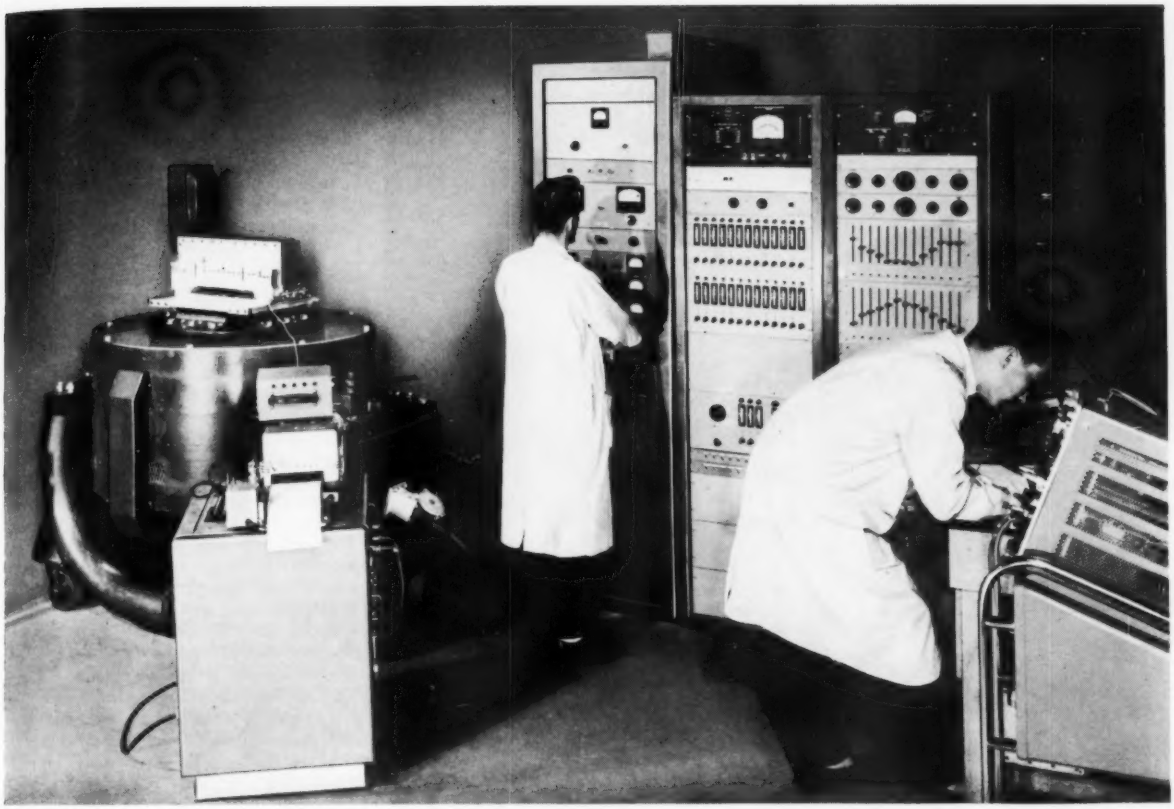
Cincinnati Sub-Zero has established a network of overseas representatives, who in most cases are native to their territories. In addition to selling, they establish service agencies to maintain equipment and do an educational job. The last includes maintaining a flow of technical data from and to the United States.

The company, in turn, has set up an extensive educational program for its reps, and from time to time the reps visit the Cincinnati plant to see and hear of newest developments.

A Pause to Refresh

Comes now a witty and erudite gentleman whose identity, alas, remains sealed in bond at his insistence, and deposes as says as follows:

"It has occurred to us (and it must occur to you) that the world you hold as a mirror (in your magazine) for your readers to study and reflect is, at best, a



FIRST WITH THE LATEST

ATL'S Sine and Random Vibration Machines in both New Jersey and Florida

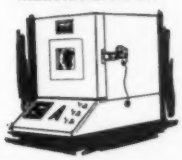
FOR TESTING LARGE COMPONENTS

This 5,000 force-pound Sine and Random Vibration Machine is the only one of its kind on the East Coast. This unit provides an output of 5,000 force pounds for sine vibration and 4,200 force pounds for random vibration. The latest automatic equalization equipment assures highest test accuracy. A 12,500 force-pound sine vibration system is also available.

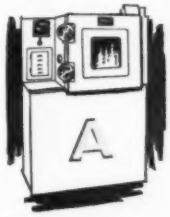
THE MOST COMPLETE FACILITIES

For random motion vibration testing, the 5,000 force-pound Sine and Random Vibration Machine, in combination with our 1,500 force-pound sine and 800 force-pound random system, represents the most complete random facility available. Moseley X-Y Plotters are available for both machines. Seven additional vibration systems assure you of rapid service.

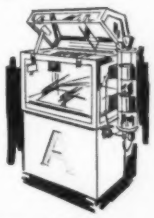
Manufacturers of:



ECON-O-LINE Low-High Temperature Test Chambers Liquefied CO_2



Low-High Temperature Test Chambers Liquefied CO_2 or Cascade Refrigeration



Salt Spray Chambers (all lucite construction)

Remember Associated Testing is open 24 hrs. a day and your engineers are welcome to be on hand while tests are in progress.

ASSOCIATED TESTING LABORATORIES, INC.

Testing Divisions

121 Route 46
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TWX: LT FS NJ 943

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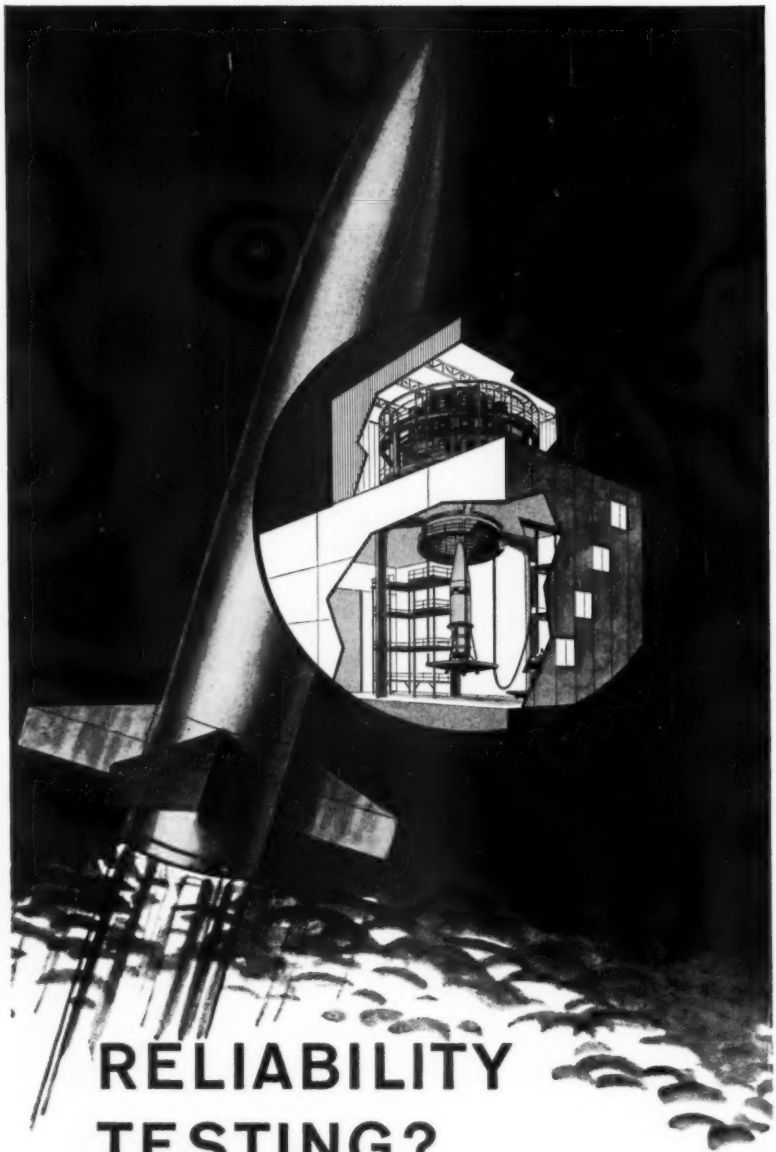

RELIABILITY TESTING?

Let CVC tailor complete turn-key facilities to your needs

Every problem in space-age reliability testing is a *big* problem. It calls for the understanding CVC has demonstrated by the start-to-finish development of environmental facilities for every phase of space simulation. We've built small . . . we've built big . . . chambers even as big as 30 x 50 feet . . . and we're equipped to build as big as you need. Just check with your nearest CVC Sales Office, or the Custom Products Division, CVC, 1175 Mt. Read Blvd., Rochester 3, N. Y. (Phone: GLenwood 8-2550)

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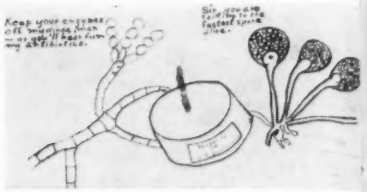
cold, a business, a technical and scientific world, to say the least. This is as it should be, we might say. But IS it?

"I ask you why you do not have a corner in your busy publication dedicated to treating the environmental engineer as a human who occasionally laughs—who might like to have his synaptic junctions titillated onct-awhile????"

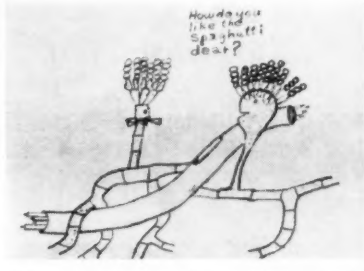
With nothing left to say but "Yes," we are grateful to a thoughtful Santa who



"Keep your enzymes off my diode, man—or you'll hear from my antibiotics." "Sir, you are talking to the fastest spore alive."

provided not one but two opportunities to titillate the synaptic junction, wherever it may be. At the risk of opening a Pandora's box, we offer (1) herewith a glimpse of microbiologic humor in connection with Dr. Frank E. Swatek's quite serious exposition in this issue entitled "A-B-Cs of Fungus Testing," and (2) elsewhere in these pages an alliterative ditty from the talented pen of Peter L. Shugart, ad and pr director of Endevco Corporation. Thank you, Dr. Swatek, and than-Q, Pete.

Naturally, any light-hearted contribution will be welcomed by Ye Editor, whose latent humor is second to none. This stern plea must be made, however: Keep it tillitating—er, titillating won't you, please, fellows?



"How do you like the spaghetti, dear?"

Give, Give, Give

Speaking of contributions, we've had some excellent ones in recent issues of Quarterly and the "futures" bin holds some of equally high caliber.

Meanwhile, we call the attention of sales managers, design engineers, purchasing agents and all and sundry in The Environment to a new EQ feature, "New Product Spotlight." This feature will appear as regularly as material permits on the "New Products" page, and we hereby solicit candidates for it, with the following proviso:

The information must be complete and thorough. It must break the product down into its component parts and then break

Do Oil and Films Mix?

"Controlling External Noise for Recording Studios' was the subject of a paper read recently, not at an environmental meeting but at a convention of the Society of Motion Picture and Television Engineers. The complaint: Too much noise and vibration from new oil wells drilled on studio properties.

the parts down. A surface description, performance data, sizes and prices are not enough, though part of it. The "Spotlight" is intended to be an X-ray.

For a better idea of what we are looking for, and what readers can expect in "New Product Spotlight," we suggest you study the first of the series in this issue—and go it one better when you offer your material.

Chicken or the Egg?

Can a scientific discipline "arrive" without first having won recognition on the campus? In the case of environmental engineering, a relatively new discipline and industry, arrival would seem to have been a bootstrap operation (witness, among other evidence, the advanced courses and seminars being sponsored by equipment manufacturers and I.E.S. chapters), but debate on the point is futile.

What is important, if The Environment is to fulfill its apparent destiny, is that it become recognized, academically speaking. Hearteningly, this is happening at an accelerated pace, even to the point of curriculum making (*EQ*, Oct. '60, Pg. 6).

In "An Engineering Educator Looks at The Environment" elsewhere in this issue, Prof. Robert L. Sutherland, head of the University of Wyoming's mechanical engineering department, makes a cogent case for environmental research and experimentation on the campus.

In this area, too, those who have worked so hard in the past to advance The Environment can make significant—and literal—contributions. Since recognition of need and availability of funds do not necessarily go hand-in-hand, gifts of even simple equipment—a unit, say, that is outmoded for your purpose—to the engineering school of your choice, will pay handsome dividends in basic knowledge, applied research and the supply of trained engineers.

Our Bookish Authors

The many readers who enjoyed Spencer A. Tucker's "Reliability Testing for Managerial Decisions" in the last (Oct.) issue of EQ will be pleased to hear that Spence has just published a book, *Successful Managerial Control by Ratio-Analysis* (McGraw-Hill, $11). Indicative of the importance of this new volume is the fact that the foreword was written by H. B. Maynard, one of the country's most highly regarded industrial engineers.

Does Noise Annoy? Not When It Deadens Sound

Noise is no problem at the new offices of Time, Inc., in New York's Rockefeller Center. It has been created deliberately to help nullify the sound of telephones, typewriters and people in partitioned offices.

A low, controlled hum is given off by a noise maker incorporated into air conditioning diffusers in the ceiling. The special noise masks objectionable sounds while avoiding dead silence in which the ring of a telephone could be as startling as an explosion.

A Cheerful New Year

New and old readers continue to provide cheer for our hard-working staff. Writes PMJ, of Spring City, Pa.: "I was very pleased to receive the complimentary copy of *Environmental Quarterly*. It is an excellent magazine and I would like a subscription."

Echoes WGS, of Schenectady, N. Y., among others:

"It is an excellent publication and a valuable reference file for personnel associated with environmental testing."

On such happy notes, the entire staff of EQ pauses at this time to wish all its critics, well-wishers, readers, advertisers and contributors a most satisfying New Year.

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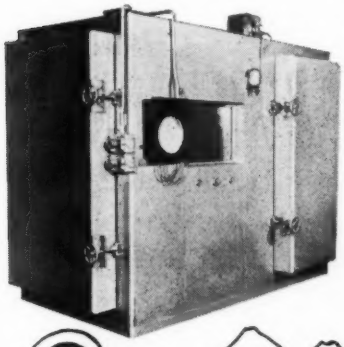

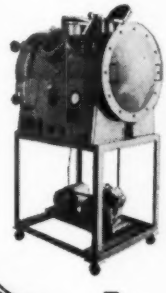

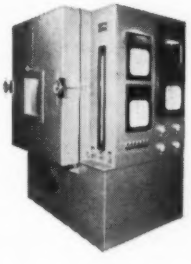

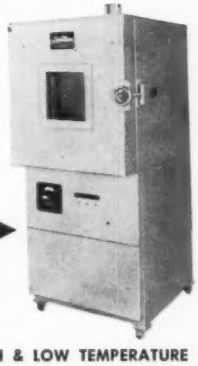

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AROUND THE ENVIRONS...

Annual IES Technical Meeting to Feature Wide-Ranging Studies of The Environment

Three days packed with presentations of technical papers and an accompanying equipment exposition will feature the annual meeting of the Institute of Environmental Sciences April 5-7 at the Sheraton Park Hotel, Washington, D. C.

Under the general theme of "Global and Space Environments, a Challenge to Industry," the IES will offer convention-goers 86 papers, more than at any of the four previous annual meetings, according to a preliminary advance program distributed by the society.

The papers, arranged by date of scheduled delivery and session topics, are:

Wednesday, April 5:

The Thermal Environment

"Problems of Passive Isothermal Temperature Control," N. E. Wood, Douglas Aircraft Co., Inc.; "Trends in Electronic Equipment Thermal Design and Packaging," W. E. Krauss, The Martin Company; "Thermal Control of an Orbital Vehicle," F. J. Sackleh or A. Gross, Wright Air Development Division; "Experimental Equipment and Methodology for Optimizing the Thermal Environment in Manned Hypersonic Aircraft," H. A. Storms, North American Aviation, Inc.; "Optimization and Off-Optimum Operation of Space Peltier Refrigeration Systems," M. E. Stelzriede, North American Aviation.

Mobility

"The Role of Environment in Land Locomotion," Capt. R. A. Liston, Ordnance Tank Automotive Command; "Mobility of Missile Launch Equipment in the Arctic," F. C. Bunn, Army Rocket and Guided Missile Agency; "Mobility as an Environment Tool (Use of Shrouds)," F. P. Merry, White Sands Missile Range; "Ground Wind Effects on Mobile Missile Systems Design," P. G. Hahn, Martin Company.

Special Test Facility Problems

"Shock Testing with Electrodynamic Shakers," H. O. Lewis, Lockheed Aircraft Corp.; "Two Phase Shock Tests of Long Elastic Bodies Performed in a 26" Diameter Air Gun," R. I. Butler, Sandia Corp.; "A Study of Repeatability Obtainable in Shock Testing," W. J. Sieger and E. H. Copeland, Sandia; "Unique Problems Associated with Environmental Testing of Acceleration — Time Sensing Devices," N. R. Anderson, Sandia; "Evaluation of Precision Centrifuge or Guidance Accelerometers," R. Uradnicek, AC Spark Plug Div.

Special Space Problems

"Environmental Storage of Hydraulic Controls in Space," A. B. Billet, Vickers Inc.; "No Loss Storage of Liquid Hydrogen in Space," D. L. Williams and I. Catton, Douglas Aircraft; "Regeneration of Breathing Oxygen from Exhaled CO_2," J. F. Foster and J. S. McNulty, Battelle Memorial Institute; "Analysis of Atmospheric Regeneration and Control Problems for Aerospace Vehicles," W. B. Fox or E. B. Thompson, Jr., Wright Air Development Division; "The Cryogenic Pumping of Non-Condensible Gages," O. O. Haroldsen and A. Cohen, Convair Astronautics.

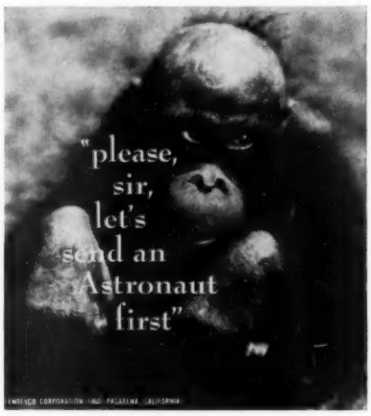
Philosophy of Environmental Testing

"Organizing the Field of Environmental Engineering," Dr. William B. Brierly, Quartermaster Research and Engineering Command; "A Realistic Engineering Approach to Environmental Testing," B. Lavitol, Ticatinny Arsenal; "Simplified Approaches to Environment Simulation," E. M. Szymanski, International Business Machines, Inc.; "Trends in Environmental Testing," R. M. Daniel, Northrop Aviation.

Random Excitation

"The Effects of Filter Bandwidth in Spectrum Analysis of Random Vibration," W. Forlifer, Aircrafts Armaments; "Correlation of Sine w. Random Based on Fatigue," J. Munro, Lear, Inc.; "Correlation Between Random and Sinusoidal Vibration Excitation by Means of Comparing Electrical Noise Generated Rather Than Through Fatigue Failures," J. E. Foster, Collins Radio Co.; "A Simplified Approach to the Amplitude Distribution Analyzer for Random Vibration," C. W. Diem, Chrysler Corp. Missile Div.

Words Without Music



Thursday, April 6:

Environment Of Space

"Environment and Its Effect on Man-Machine Design," M. A. Larue, Martin Company; "The Effect of Ions on Human Behavior," R. A. Duffee and H. G. Schutz, Battelle; "Biological Hazards from Space Radiation Based on Tissue Equivalent Ion Chamber Measurements," S. W. Leeper, Air Research & Development Command; "Toxicoligical Problems for Man in a Space Vehicle Because of Gases Evolved from the Thermal Degradations of Polysulfide Polymers," M. Honma, Lockheed; "Problems in Determining Space Environmental Design Criteria," A. D. Goedeke, Douglas Aircraft.

Simulation Methods For Normal Environments

"Wind Tunnel Studies with Scale Model Simulated Snow," Dr. Robert Gerdel, U. S. Army Snow, Ice & Permafrost Establishment; "Simulation of the Rain Environment," M. H. Simpson, Pitman-Dunn Laboratories; "The Simulation of the Shock and Vibration Environment," Dr. R. M. Mains, General Electric Co.; "Water Entry Testing Using Rocket Sleds," D. W. Bauder, Sandia.

Acoustics And Dynamics

"A Unique Acoustic Chamber for High Energy, Progressive Wave Testing," J. B. Overton, U. S. Naval Missile Center; "Acoustics in Manned Space Vehicles," W. F. Rector, Convair Astronautics; "Problems in Acoustical Environmental Simulation," W. G. Dunn, Tenney Engineering, Inc., "Acoustic Hyper-Environment and Its Simulation," D. C. Skilling, Northrup Corp.; "Evaluation of Fastening Looseness on Equipment Dynamic Response," C. S. O'Hearne, Martin Company.

Space Facilities

"The Simulation of Re-Entry Conditions in the Wind Tunnel," Dr. K. R. Enkenhus, Naval Ordnance Laboratory; "Facility for Simulating Missile Guidance Compartment High Altitude and Temperature Environment," J. D. Losse, AC Spark Plug; "Vacuum and Space Environments," W. E. Scott, Grumman Aircraft Engineering Corp.; "Boeing High Temperature — Altitude Simulation Facilities," J. D. Stuart, Boeing Airplane Co.; "Operation of a Solar Space Environmental Simulator," H. Mark, National Aeronautics and Space Administration.

Environmental Criteria And Specifications

"Criteria for Design of Military Equipment for Reliable Performance During Environment-

Continued on Page 11

England's Society Of Environmental Engineers Grows

A Society of Environmental Engineers, reminiscent in name of a former group in the United States, is celebrating its second birthday in England. The British SEE has just published its first proceedings, a series of regional meetings have been started, and membership totals more than 125. The next annual meeting will be held in March.

Organized at the beginning of 1959, the SEE grew out of the desire of senior engineers and scientists for a forum in which to exchange environmental views and experiences. Vibration is of particular interest to the group.

The society held its first general meeting on May 29, 1959, at the house of the Royal Society of Arts. Coincidentally, that was about a month after two U.S. societies, the Institute of Environmental Engineers and the Society of Environmental Engineers, merged to form the Institute of Environmental Sciences.

SEE's Goals Stated

In a leaflet published a year ago, the SEE said it "expects to accomplish much in both the exchange of information between various bodies in this and other countries, and through its concerted action as an organization to improve the general status of this form of testing in the engineering field."

Membership in the SEE consists of sponsor members, or companies, professional organizations and governmental agencies interested in environmental testing, and individual members. The latter includes fellows, ordinary members, associate members and student members.

The society's first regional meeting was held in Bristol last Oct. 31, with Dr. B. L. Clarkson, of the aeronautics and astronomics department, University of Southhampton, as the speaker. Other regional discussions are being organized for the Coventry and Manchester districts.

Other Activities

Among recent general activities of the SEE, a meeting was held at the Imperial College of Science, London, on Nov. 23, followed by the annual dinner at a hotel in South Kensington. For the near future, there will be meetings at Imperial College on Jan. 21 and Feb. 15, with K. W. Jones, and W. W. Wright and J. C. King, respectively, delivering papers, and the annual general meeting in March.

Visits are another part of the SEE program. Recently members visited the Kelvin Hughes Environmental Test House.

In addition to the proceedings, the society publishes a periodic bulletin.

W. G. P. Weake, of Derritron Ltd., is chairman of the SEE, and Dr. P. Grootenhuis, of the mechanical engineering faculty, Imperial College, is executive secretary.

PDC Is Publishing New Environments Abstracts

A new monthly bulletin of abstracts, *Environmental Effects on Materials and Equipment*, is being published by the Prevention of Deterioration Center of the National Academy of Sciences-National Research Council. The first issue is out this month. To appear monthly, it is available to industry, universities and private groups and individuals at $25 a year.

For the time being supplementing PDC's *Prevention of Deterioration Abstracts*, with emphasis on induced environments, the "Environmental Effects" will eventually supercede the older series, now in Volume 18.

Seek Colorado IES Chapter

A move is under way to form a Colorado chapter of the Institute of Environmental Sciences. Meetings were held in Denver on Nov. 10 and Dec. 8 to form a pro-tem steering committee for the project. Jerome Bakalish, former president of the Los Angeles chapter who now works in Denver, was among those attending. A committee was set up to contact prospective members.

Ling Forms Service Company

Ling-Altec Electronics, Inc., has set up a new company to install and service its vibration and high intensity sound equipment. C. S. Perkins, vice president of Altec Companies, Inc., heads the new service unit, which has field offices in 71 cities and headquarters in New York.

Forms Military Sales Group

MB Electronics, New Haven, has formed a military sales department to handle specialized government requirements for complex electronic power systems.

IES Technical Meeting

Continued from Page 10

al Simulation," T. W. Johnson, Jr., Naval Bureau of Weapons; "Environmental Specifications and Their Application," M. P. Ornstien, Wright Air Development Center; "Planning, Organizing and Administering an Environmental Test Program," A. Koch, Ticatinny Arsenal; "Interactions in Combined Environments," J. S. Arnold, Stanford Research Institute; "What's Typical About a Typical Dust Environment," R. E. Engelhardt, Southwest Research Institute.

Shock And Vibration Problems

"Choosing A Substitute Sweep Frequency for Sinusoidal Vibration," Neal Granick, Goddard Space Lab.; "Vibration and Noise Studies for Project Mercury," S. Clevenson and D. Hilton, Langley Research Center; "A Vibration Amplitude Recording System for Design Evaluation Studies," Irving and Milne, Johns Hopkins University; "Reliability of Piezoelectric Accelerometers for Shock Measurement," E. I. Feder and E. J. Straus, Gulton Industries, Inc.; "In-Flight Sound Level and Vibration Conditions in Naval Air Electronic Equipment Compartments," J. Nelson Tait, Naval Air Development Center.

Friday, April 7:

Spacecraft Problems

"Optical Phenomena of Interplanetary Matter," Dr. W. O. McMinn, American Machine & Foundry Co.; "A Review of Extraterrestrial Matter," D. E. Winer, American Machine & Foundry; "Possible Hazards from Comets, Cometoids and Meteor Streams," D. H. Robey, Convair Astronautics; "The Sealing of Small Openings Space Vehicle Cabins," J. S. Islinger, Armour Research; "The Testing of Materials for Spacecraft," F. J. Clauss, Lockheed.

Ground Environment Effects

"Controlled Temperature Requirements for Environmental Testing of Component Parts," R. H. Paccone, IBM; "Low Ambient Temperature Effects on Starting Liquid-Cooled 2 and 4-Cycle Engines," Mr. Campbell, Detroit Arsenal; "Corrosion Problems Encountered in Silo Storage of Missiles," L. E. Gatzek, Space Technology Laboratories; "Effects of Environment on Mechanical Properties of Metals," H. E. McCoy, Oak Ridge National Laboratories; "Transient Radiation Effects on Guided Missile Systems," Glen Elder, White Sands.

Marine Environments

"The Sea as an Environmental Factor," Dr. D. D. Chapman, Boeing; "The Polaris and Its Sea Environment," Robert L. Waid, Lockheed; "Aerosols and Air Ions on Nuclear-Powered Submarines," Capt. J. L. Kinsey, U. S. Navy; "The Shipboard Vibration Environment," E. Buchmann, David Taylor Model Basin; "Shipboard Shock Environment," H. L. Rich and R. E. Baker, David Taylor Model Basin.

Life Sciences and Space

"Human Protection in Abrupt Acceleration Environments," Charles A. Dempsey, WADD; "Free-Floating Sensations and Trajectories of Orbital Workers," Capt. Simon and Lt. Gardner, WADD; "Life Support System Tests Under Simulated Conditions (Project Mercury)," L. Richardson and Maloney, McDonnell Aircraft; "Noise and Vibration of Personnel in Aero-Space Systems and the Simulation of the Environment in Aero-Space Medical Research," Von Gierke, Cole and Grob, WADD; "Space Environment and Life Sciences Facilities," E. Pearman and William Helvey, Republic Aviation Corp.

Space Environments Simulation

"Instrumentation for Monitoring the Space Environment," B. Wacholder, Radio Corp. of America; "Outer Space Environment Simulation," P. Marfone and D. Grady, General Electric Co., MSVD; "Design Solution for Space Simulation," John Galhard, General Electric, MSVD; "High Vacuum Orbital Simulator," W. G. Camack and C. A. Ellis, Jr., Lockheed; "Future Space Chamber Needs," A. H. Abernathy, Holloman Air Force Base.

Environmental Measurements

"Environmental Measurements in Probe Type Sounding Rockets," C. E. Roth, Jr., Aerojet-General Corp.; "Techniques Used in Calibrating Vibration Measuring Transducers to 10,000 Cycles per Second," K. Lanz, MB Electronics; "The Calibration and Use of Acceleration Pickups for Shock Motion Measurements," R. R. Bouche, Endevco Corporation; "Problems Encountered in the Measurement of Radio Frequency Interference," R. R. Bouche; "Some Structural Load Measurement Problems on Advanced Flight Vehicles," W. H. Michie, Wright Research & Development Command.

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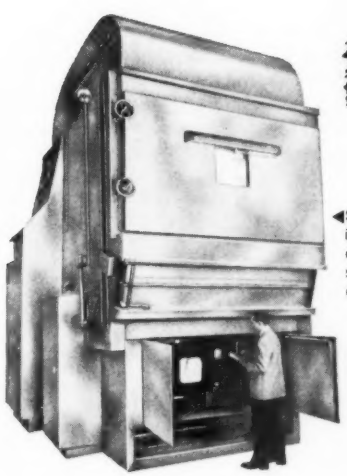

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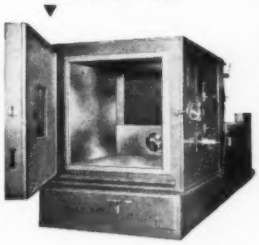

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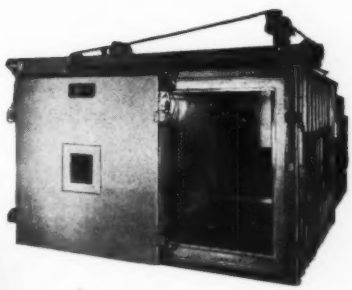

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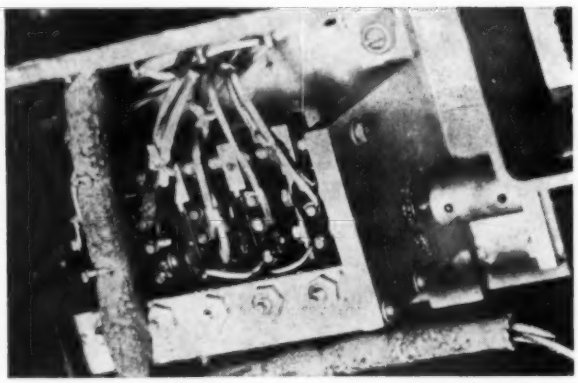


Heavy growth of fungus covers wires in drawers of Atlas missile check-out units.

A-B-Cs of F

With memories of World War II experience with fungi fading, design engineers are discounting the destructive power of the mighty micro-organism, says a noted mycologist. Here are presented some of the problems and pitfalls to guard against and procedures to follow in tests to overcome an environment that has long been flourishing.

THE DESTRUCTIVE NATURE OF FUNGI is manifested in many ways, some more critical than others. For example:

(1) They may attack products, making them unsightly and leaving a significant objectionable odor.

(2) They may attack and deface labeling or other essential instructional information placed on a product.

(3) They may attack and lessen the tensile strength and durability of a product, causing it to fail short of the time indicated in endurance testing.

(4) They may, in their metabolic activity, emit organic acids that etch or in some way disfigure a wanted smooth or polished surface.

(5) They may grow over the straining pores of filters, forming a closed mat to plug the filter pads.

The Unseen Enemy

Full-scale awareness of the destructive might of the tiny fungi came early in World War II. Here was an unseen enemy of mass warfare which respected neither side. Fungi are opportunists, natural inhabitants of lands under invasion. Fungi are a group of micro-organisms, many of which attack, digest and eventually return to their elements all types of organic materials.

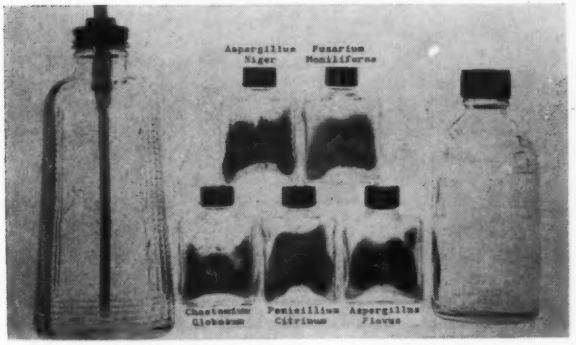
To the layman, the term fungus, or fungi, is ambigous. Few realize that mold is just a popular expression for fungus and that yeast, toadstools and mushrooms are all types of fungi. Mycology, the science that studies fungi, is one of the oldest organized branches of biological science. To the mycologist, fungi are much more than test organisms for MIL-E-5272A. Rather, they are living, reproducing plants, each with a pedigree and a dynamic potential for expression.

These small organisms are complete chemical factories with a growth potential governed only by the environment in which they find themselves. The environment permitting, they will grow forever, and they are not bound, as are human beings, to a predetermined genetic size. Fungi grow by the apical extension of round tube-like structures called hyphae, which collectively are called mycelia. Individual cells making up the hyphae show a rather highly evolved condition, with components comparable to cells of the highest plants except for one thing.

Nothing a fungus likes more than the label of an electronic unit — unless it's the terminal connection. (All photos courtesy of Dr. Swatek.)

Fungus Testing

by Frank E. Swatek, Ph.D.
Staff Consultant
American Laboratories Division,
American Electronics, Inc.



FUNGUS RESISTANCE TEST: Left—atomizer with cultures in water. Right—distilled water. Center—fungi. Spores are transferred into the atomizer; then a mixture is sprayed on parts to be tested.

They lack the chloroplasts of higher green plants in which the photosynthetic pigment chlorophyll is found. Fungi lack chlorophyll, and this is the largest generalization used to separate fungi from other plants.

A Look at Chaetomium Globosum

To appreciate just how fungi work (metabolize), take the case of *Chaetomium globosum* (V.S.D.A. 1042.2). This cosmopolitian fungus is known to attack and digest cellulose and degrades of cellulose, or any of the natural materials man uses which contain free cellulose. A most common use of cellulose is in cork gaskets.

Cork really consists of the cork cambium cells and bark cells of the cork oak tree, so that the cork used in gaskets is the dried remains of cells rich in cellulose, lignin and certain pectins. Chemically, cellulose is a long, continuous chain of glucose molecules linked in such a way that one molecule of water is removed with the union of each glucose to its neighbor.

Cellulose requires a chemical modification to make it a water soluble compound. The fungus, lacking any sort of mouth or movable food gathering parts, must secure its food by first changing it from an insoluble to a soluble state. This it does by sending out certain chemicals.

In the case of cellulose, the first step is to change the cellulose into cellobiose and, finally to break it down into its component glucose molecules. Glucose, which is water soluble, enters the cell to be used as the starting material for a many-stage conversion cycle by which it surrenders its stored chemical energy. This energy is used then by the cell to build more cell components and maintain existing parts.

An Almost Human Process

The transformation is known as the citric acid cycle, or the Meyerhof-Embden-Tricarboxylic acid cycle. This same sort of conversion, with minor modifications, is the way our body, at the cellular level, receives the energy we need from the food we injest. At this time, the way the fungi do it and the way man carries out his cellular activities appear to be so close that disease producing fungi are susceptible to only a few antibiotic drugs, and thus are exceedingly hard to treat.

So it is, then, that fungi live off preformed organic material of all sorts (leather, cotton, hemp, copra) manufacured by both higher plants and animals and, of course, some of man's new miracle fibers and blends of natural and man-made fibers. Fungi, like man, are dependent on presynthesized materials. Some fungi are markedly vitamin deficient and require separate doses of vitamins to survive. Others have specific substrates (that is, food requirements) while some are quite plastic in their needs and attack a great variety of materials.

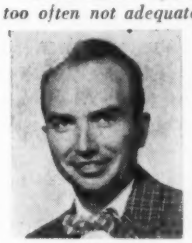
Some fungi and bacteria like the jet fuel mixtures we are now blending; others like the crude products of petroleum. It is truly hard to find a poly-carbon chained compound that some fungus in the world might not like to have for lunch. Anti-fungal materials have to be incorporated directly into the products or applied after fabrication in order to assure fungus resistance when these units are submitted to the proper physical environment for fungus growth.

Dependent on the Environment

Fungi lack a control system to maintain body temperature above or below the environment. Thus, they are wholly dependent on the physical environment for the temperature favorable to their metabolic chemical processes. A temperature requirement of 86° F, ±4°, is found in the general fungus resistance test procedure and its immediate modifications. This, as you can readily see, is the temperature of an average summer day—one that fungi might find in actual field conditions. At this temperature, both the extracellular and intracellular enzymes of a fungus may function at or very near the optimum level, and so a more or less rapid growth is encouraged.

As all first-year chemistry students know, chemical re-

Frank Swatek specializes in a field often discussed but too often not adequately understood in the Environment—a fact that makes him a very busy man. His primary position is professor of microbiology at California's Long Beach State College. His other posts include staff consultant and consulting mycologist at American Laboratories, Fullerton, Calif., and consultant to the alergy and dermatology departments of the V A hospital in Long Beach. A graduate of San Diego State College, he holds an M.A. and a Ph.D. in microbiology from UCLA. His memberships include the Mycological Society of America, American Public Health Association, Southern California Branch of the Society of American Bacteriologists and Sigma Xi.



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Testing each component and sub-assembly avoids the pitfall of final failure to meet qualification specs.

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actions continue at ever increasing rates as the temperature rises because of the excitement of the atoms at higher and higher temperatures. What, then, is the limit of fungus growth? General limits have to be established for each fungus. For the organism used in general fungus resistance testing, 104° to 110° F. is the maximum. At temperatures over 104° F., the viscosity of the cytoplasm of most forms of life begins to change.

All of life's processes go on in the medium of an integrated colloidal chemical system. Temperature can physically change this system by exaggerating activities of atoms and dehydration of the loosely bound H_2O. When temperature reaches 122° F., proteins begin to coagulate and engage in non-reversible chemical reactions. For fungi, then, temperature is truly critical at the upper limits.

What about low temperatures? Here we find much more tolerance in fungi. Generally they will survive temperatures almost to the freezing point of water, but most will not metabolize below 45° F. Since most fungus chambers are inside buildings, it would be rare to have a false test due to death of the fungi by freezing. However, one must keep in mind the fact that the test is set up under a timed condition in which allowable raising or lowering of temperature is small—only ± 4° F.

Twenty-eight Day Exposure

If some other temperature were selected, some other time exposure would have to be used to secure a comparable test, and since the highest temperature compatible with the majority of fungi is used now, the only way to modify would be in a lower temperature, which would mean an increase in time. The present test calls for a 28-day exposure. Most manufacturers consider this to be too long to wait.

Why 28 days? Man-made fibers fabricated with fungus inhibitors are only as good as the life of the inhibitors as far as fungus resistance is concerned. With its high humidity and high spore concentration, the present 28-day test corresponds to a one or two-year product storage cycle under tropical or semi-tropical environmental conditions.

The humidity requirement of 95 per cent, ±5 per cent, puts the specimen in a truly damp environment. Two paramount reasons, among the many behind this requirement, are: (1) fungi need a high humidity to be able to germinate and continue to grow, and (2) some of the fungus preservatives are slightly water soluble and these conditions allow leaching to occur.

If the manufacturer has not supplied a sufficient amount of fungus preservative to protect his product for up to two years of storage, growth usually begins around the twentieth day of the test. In the remaining eight days, if the substrate, now divorced of its protection, is exposed to the fungi, it will produce a great many "fungus whiskers." The humidity also is a test of lacquers and varnishes, which usually are compounded with resins and natural oils that are food for fungi. Epoxy resins are replacing varnish in many applications with much success.

Handling the Test Specs

Knowing these things, what sort of conditions do we find in fungus testing? MIL-E-5272A, B, C, or any of the other qualification specs for general fungus testing, makes some very large assumptions that have to be evaluated and interpreted. Among the most important are the amount of fungus to be used and the size of the culture tubes used to grow the fungi.

If the specification is accepted literally, there is a terrible problem with respect to amount of spores to use. For example, the qualification of the Atlas ground checkout

panels calls for inoculation with one set of five different fungi in 100 cc of water. This volume of spores will, in reality, effectively cover only about one-half a cubic foot of electronic circuits and associated wiring, meaning there would be a great deal of area ineffectively covered. By the same token, the speces call for this same volume, 100 cc of a spore suspension, for a 1/8-inch diode. Here the conscientious engineer or chemist truly runs into a dilemma if he is inexperinced in the potentials of fungi.

Elsewhere the specs allow overnight refrigeration of a prepared spore suspension. The mycologist who knows the fungi will choose from the 10 available five hardy ones from which he can expect a good survival curve, because certain of the fungi in the list are antagonists of some others and will cause their death if left for extended periods of time in the same solution.

Chemistry Lab Procedures Not Enough

Some companies run fungus tests in their chemistry laboratories. What happens is that a chemist will grow the fungi, usually on chemically defined (synthetic) media, in which most of the fungi in the test find it hard to sporulate in a normal manner. Unaware of the color that should be attained in the heavily sporulating culture, the chemist will, in traditional chemical fashion, extract the mycelium and grind it in a blender to secure fungus elements for inoculation. This is a conscientious effort to perform a good test, but it falls short of the best because of the poor survival rate of the damaged hyphae cells as compared to normally found spores.

Then, there are the engineers who gingerly remove the lids from the culture tubes and set them on the shelf near the test specimen, completely ignoring test procedure, with the result that no test has occurred.

If this test is to be worthwhile, it is necessary to understand what is written, as well as what is not written but understood, in general fungus testing. If this test is to be conducted only by qualified mycologists, then it should say so; if it is to be performed for what it is worth by anyone, then it is going to have to be controlled and spelled out much more thoroughly.

Questions To Be Asked

At this time, then, anyone wishing to have a competent fungus test should ask at least the following questions of the tester:

1. What are the sources of the fungi used?
2. Have they been properly grown—are they mature?
3. Does the fungus chamber have the capacity to control the needed environment?
4. Is a mycologist performing the test?
5. Is a sufficient amount of spore suspension being applied?
6. Have suitable controls been run to assure a good test?

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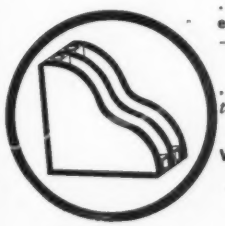

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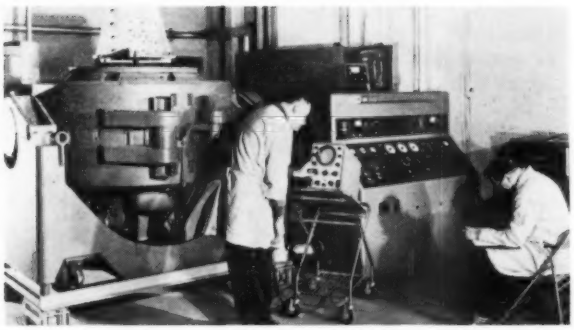


Axial lead component parts are being subjected to a 12,500 pound-force vibration system at Associated Testing Laboratories, Inc. Monitoring the results are Dennis Shepard (left) and Joseph Slizen.

by William Tonkowich
President
Associated Testing Laboratories, Inc.

Designing for Qualification

Environmental test laboratories, both independent and in-company, face a unique dilemma, says the head of a well-known independent. While watching equipments fail in the course of qualification or approval tests, they accumulate a wealth of design know-how. Yet the objectivity demanded of them in performing tests and reporting results may be compromised if they offer design advice. This article is an attempt to share experience with others, so that valuable knowledge gained in a test lab will not go unutilized.

The environmental test laboratory watches helplessly as equipments fail under test. Many, the test engineer knows, will require extensive redesign before they can qualify.

These failures occur under many environmental conditions, but some environments do more violence to a specimen than others. This is attributable to many factors, the most important of which may, no doubt, simply be described as experience, or state-of-the-art.

What follows is a summary of some of the major causes of failure and what the designer can do to overcome them. It is not intended to be all-inclusive. It is based on the experience of many engineers with the certainty that many, many others could offer similar advice to designers, based on *their* experience. And because the approach is generalized, without mention of any specific product or equipment, there is no breach of confidence or objectivity.

VIBRATION TESTING

The greatest number of qualification test failures occur during, or as a result of, vibration testing. The chief ones may be summarized as structural failure of supporting members, structural failure of functional parts, electrical noise and circuit interruptions. Let us examine them more closely.

Supporting Member Failure

1. Structural failure of supporting members is often caused by fatigue. As this is a common experience during vibration testing, the equipment designer should remember that under resonant conditions a supporting member may experience a load equal to a hundred times or more the weight of the parts being supported—and with stress reversing in direction at the frequency of vibration. This type of loading often results in a bracket or sub-chassis' developing fractures along bend lines.

Failure may be prevented by insuring that the inner bend radius on any supporting sheet metal assembly is equal to, or greater than, the thickness of the material. Other points of stress, such as the corners of punched

In another vibration test, Anthony Quail (left) and Ralph Steiner subject a power supply to a resonance search.

square holes, may turn into failure areas, too, so it is best to stress relieve sheet metal parts, wherever possible, after bending or punching.

Functional Parts Failure

2. Structural failure of functional parts. This may be due to exposure to environments more severe than those for which they were designed. A more common reason for failure, however, is incorrect mounting or assembly.

A typical failure may consist of a broken lead in the case of an axial lead part, such as a transistor, or a fractured mounting tab on a transformer. In the case of the axial lead part, the failure may be prevented by supporting the part by its body as well as its leads. In general, parts should be mounted in accordance with the following table if they are not in an encapsulated assembly:

	Typical Conditions for Supporting Parts Body
Weight	Greater than ½ ounce
Length	Greater than ¾ inch
Diameter	Greater than ¼ inch
Periphery	Greater than 1 inch

The parts bodies may be supported by using spring clips of the type manufactured by Augat Brothers, Atlee, or Birtcher. Since the parts themselves are usually vibration tested while mounted as described, any data supplied by the part manufacturer is valid only if the parts are mounted accordingly in actual use.

In the case of transformers, or aircraft relays, if an excessive torque or pressure is applied to the mounting hardware, the mounting tabs will be stressed. Under vibration these pre-stressed points often fail structurally. This may be prevented by specifying in detail the assembly technique for the part.

Electrical Noise

3. Electronic equipments which utilize vacuum tubes, relays, potentiometers, synchros, or other devices based upon mechanical contact are susceptible to noise. The noise is usually due to a resonant condition of an electrode or a movable contact.

Since the noise generally occurs at vibrational frequencies above 60 cps, vibration isolation mounts may be quite effective in eliminating this problem. However, if size or weight limitations preclude the use of isolators, only parts which can perform properly in the vibration environment specified should be used. If a manufacturer cannot supply the environmental test data, then the user should plan on testing the parts himself before incorporating them into his design.

Circuit Interruptions

4. Short or open circuit conditions may be caused either by damaged insulation or by parts making contact due to relative motion. Long lengths of unsupported wiring harness will often abrade against an edge or surface. Poor solder connections and inadequate wire support may result in lead breakage.

These problems may be minimized by anchoring lead wires close to their soldered terminations and supporting harnesses every one to three inches, depending on the rigidity of the harness. Where large parts such as transformers, reactors, or vacuum tubes are mounted on a flexible chassis it is possible for relative motions of one half inch to occur at resonances. The designer should strive for rigidity of supporting members, but simultaneously plan for relative motion between parts.

When the recent issue of Fortune magazine presented a profile of Associated Testing Laboratories, Inc., and the firm's youthful founders, Bill Tonkowich and Bernie Novack, it surprised no one, for ATL has made a name for itself as one of the country's fast moving environmental concerns. The accompanying article by the 37-year-old presidential half of the ATL team stems from a wealth of experience and an incisive mind with a knack of getting down to fundamentals. Bill won his B.S. in engineering at Tufts College, took graduate courses in advanced physics at Brooklyn Poly and went on to an M.S. in engineering management at the Newark College of Engineering. After research and administrative engineering assignments at L. E. Waterman & Co. and Simmonds Aerocessories, he joined General Testing Laboratories as chief engineer in 1955. There he met Novack, and Associated Testing, which is an equipment manufacturer as well as a test lab, was born in 1956. The company, whose growth has been reported on from time to time in these pages, recently moved into a new, modern plant in Wayne, N. J.

Tonkowich

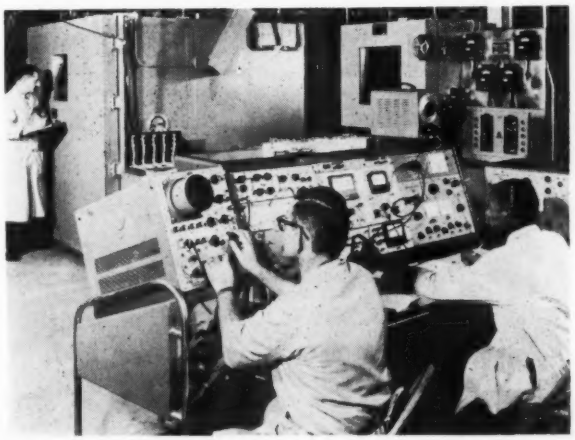
Shock and Acceleration

Shock and acceleration testing produces failures similar to those of vibration tests, but less frequently. Precautions described for vibration testing will in most cases minimize failures during shock and acceleration. However, there are special devices, such as panel meters, electro-mechanical time delay relays and accelerometers which may be affected more seriously by shock and acceleration than by vibration.

Before incorporating these parts into equipment the manufacturers' data should be carefully checked to establish under which environments and at what levels the parts will operate without degraded performances.

Temperature

Most qualification test specifications require that temperature be combined with another environment, such as humidity or altitude. However, the design problems peculiar to temperature are the characteristics of parts such as semiconductors and resistors, and the problems of materials. Electronics engineers generally will design



ATL's Nicholas Novecki, Arthur Gottfried and Morris Grantley (left to right) conduct a functional test of transistors exposed to high temperatures.

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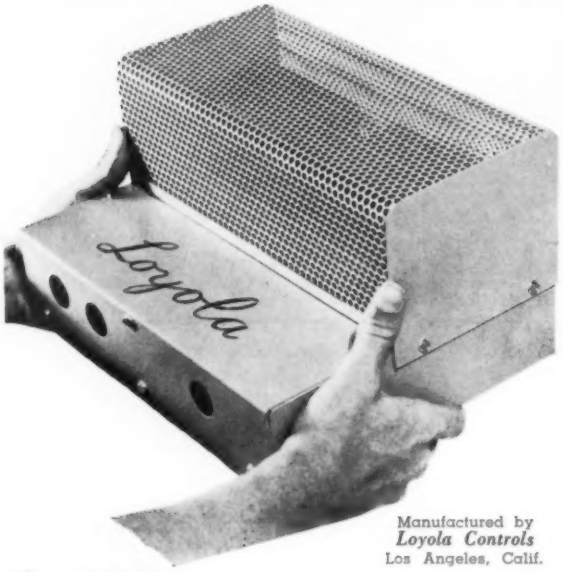

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circuits using proper electronic parts and temperature compensation.

But what "looks good on paper" often fails under test, and it is strongly recommended that all breadboard circuits be subjected to temperature testing before being designed into production models.

Materials must be carefully chosen. Expansion properties, insulation resistance and melting points must be considered. If there is any doubt, materials such as teflon, kel-F, glass, ceramics and melamine should be used to insure proper operation at temperatures above 100°C.

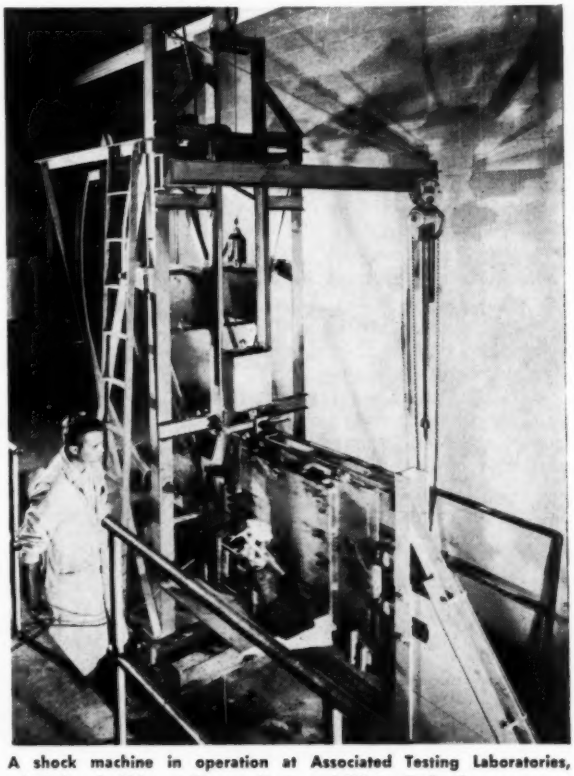
Humidity & Salt Fog

The greatest problems resulting from humidity and salt fog testing are corrosion and insulation resistance degradation. The corrosion problem should be approached from the viewpoint of both type of finish and the quality. Both humidity and salt fog "seek" the weakest point in the exterior finish. Insulation resistance and dielectric breakdown failures result where measurements are to be taken immediately after testing, or where moisture has accumulated.

If this is the case, the equipment should be sealed against humidity and salt fog by means of gasketed housings. Where unsealed equipment is to operate under humidity conditions, configuration of the equipment should be such as to minimize moisture accumulation.

Altitude

The basic problems created by high altitude exposure are lower heat dissipation by convection and lower dielectric breakdown voltage of the air. By utilizing conduction techniques as much as possible for heat dissipation, and by proper spacing of high voltage terminals, altitude testing failures may be minimized. For example, at 50,000 feet the breakdown voltage of dry air is 20 percent of its value at sea level.



A shock machine in operation at Associated Testing Laboratories, which has facilities at Wayne, N. J., and Winter Park, Fla.

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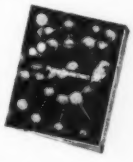

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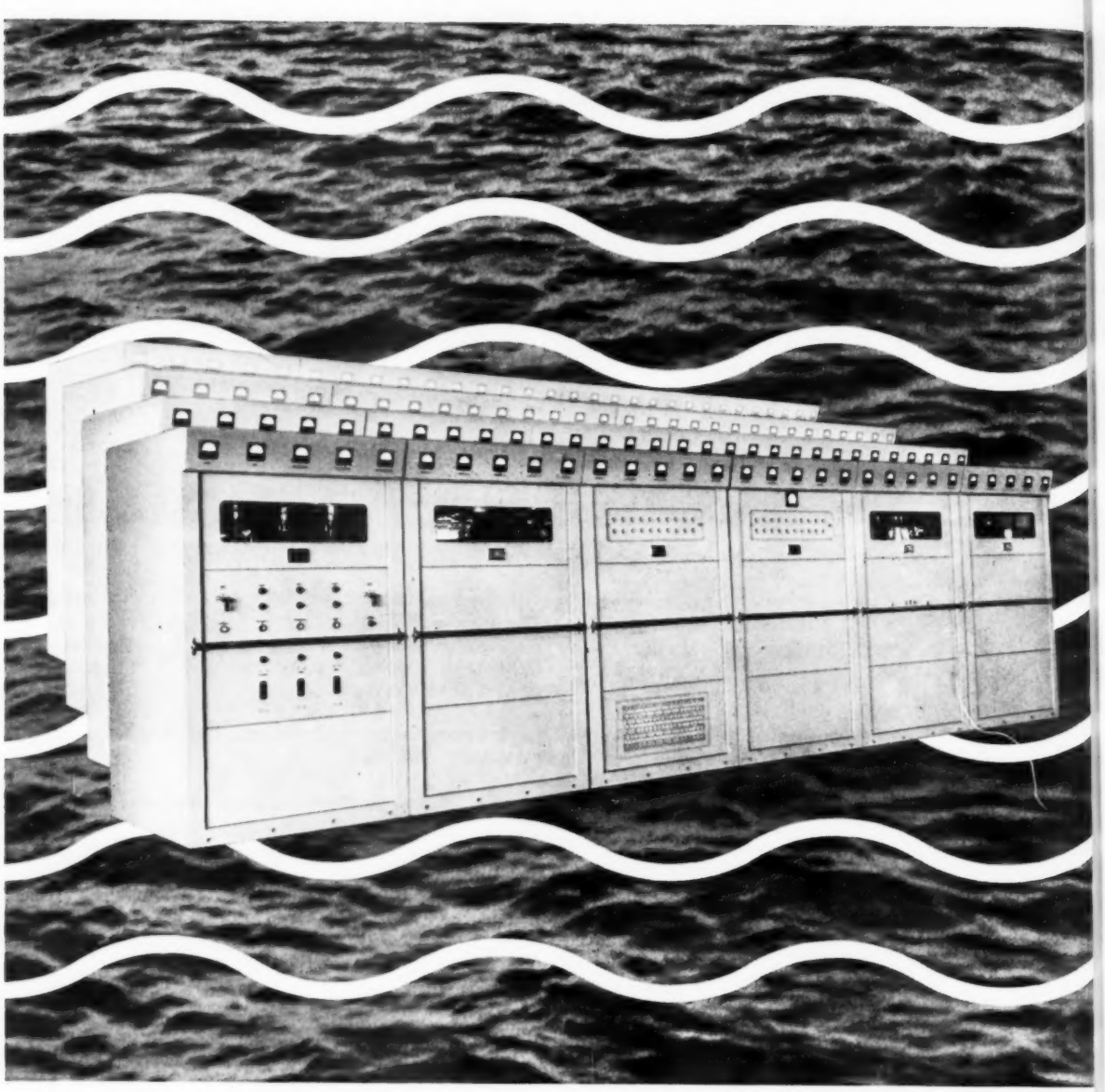

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PP120/150.....120,000 VA
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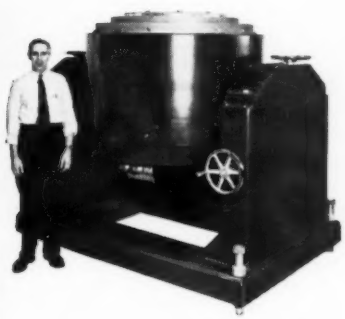

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CHANGING ENVIRONMENTS

American Vacuum Society Elects Dayton President

Benjamin B. Dayton, technical director of Consolidated Vacuum Corp., Rochester, N. Y., has been elected president of the American Vacuum Society, succeeding Wilfred G. Matheson of Sylvania Electric Products, Inc.

Dayton has held his present post at CVC since 1954, and was previously director of research and supervisor of CVC's development and quality control department.

JEROME BAKALISH has been appointed senior engineer in the environmental test standards group of the quality engineering department of MARTIN COMPANY, Denver. He was formerly with the Firestone Guided Missile division, Los Angeles, and is past president of the Los Angeles chapter of the Institute of Environmental Sciences.

• • •

DANIEL S. SCHWARTZ and **AARON WALDMAN** have joined GULTON INDUSTRIES, INC., Metuchen, N.J., as, respectively, senior research physicist of the research and development division, and supervisor of the instrumentation division's electro-mechanical group. Both were formerly senior project engineers with the Kearfott division of General Precision, Inc.

• • •

GEORGE E. GILLIAM and **HARRY A. LUCAS,** former Minneapolis-Honeywell executives, have joined the COMPUDYNE CORPORATION, Hatboro, Pa. Gilliam is regional sales manager with responsibilities for field sales in aircraft and missile fields and supervision of facilities sales personnel. Lucas is corporate sales consultant, handling sales in the missile testing and launch facility field. Gilliam was 17 years with M-H, Lucas, 18.

• • •

THOMAS A. MARSHALL JR. has been elected executive secretary of the American Society for Testing Materials, succeeding Robert J. Painter, who stepped down for reasons of health but will continue as a consultant. Marshall was formerly senior assistant secretary of the American Society of Mechanical Engineers.

• • •

ROBERT S. SADLER, vibration project engineer with AEROTEST LABORATORIES, INC., Deer Park, N. Y., has completed a course in complex vibration practices conducted by MB Electronics, New Haven.

Dayton

Brandt

Waldman

Schwartz

JOHN DAVIES and **ALFRED MELZER,** formerly of American Electronics and Convair, respectively, have joined the engineering staff of AUTO-CONTROL LABORATORIES, Los Angeles.

• • •

CHARLES E. SWANSON has joined the INTERNATIONAL RADIANT CORP., New York, as production manager. He was production manager of Roy Engineering & Iron Works, Brooklyn.

• • •

DR. C. M. WOLFE has joined BORG-WARNER CONTROLS, Santa Ana, Calif., as head of transducer engineering. He is a former research specialist at United Electrodynamics and taught at the University of Washington.

• • •

PAUL H. BRANDT and **D. HASKINS** formerly of MURPHY & MILLER, INC., Chicago, have taken over JOHNSON BROS., refrigeration and air conditioning contracting firm in Phoenix, Ariz.

• • •

E. J. BLIGARD, formerly plant manager of the machine shop division of MB ELECTRONICS, has been appointed manufacturing manager of MB's two New Haven, Conn. plants. He is responsible for the vibration test equipment, machine shop and Propulsion Test Facilities divisions.

• • •

DR. MILO P. HNILICKA has been named to the new post of scientific assistant to the vice president and director of research for NATIONAL RESEARCH CORPORATION, Cambridge, Mass. A member of the Institute of Environmental Sci-

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McFadden

McFadden Heads Micro Gee; York, Losmandy Named VPs

B. W. McFadden has been promoted from vice president to president of Micro Gee Products, Culver City, Calif. David S. York, chief mechanical engineer, and Bela Losmandy, chief electronic engineer, were chosen vice presidents, and E. A. Scott became secretary-treasurer.

Micro Gee designs and manufactures precision electro-mechanical and electronic flight test devices. Established in 1953, the company has its main plant and office in Culver City and a branch in Torrance, Calif.

ences, he has been with NRC since 1952, most recently acting as consultant in simulation of outer space environment and other space technology. He escaped with his wife and family from Communist Czechoslovakia in the late 1940s.

* * *

E. B. MOORE has been appointed publicity director of VAPOR HEATING CORPORATION, Chicago. He joined Vapor in 1949 and was previously market liaison engineer.

* * *

ARTHUR N. PURDY, former laboratory manager at General Testing Laboratories, has joined the field engineering department of WYLE-PARAMETERS, INC., of New Hyde Park, N. Y. He is a member of the Institute of Environmental Sciences and American Society for Testing Materials.

* * *

DR. SHERWIN U. MILLER has been appointed director of the life sciences division of SPACE SYSTEMS LABORATORIES, Burbank, Calif. He will be in charge of research programs whose major purpose will include development of systems to support life processes within the hyper-environments. He was formerly director of space medicine for Litton Industries.

* * *

EDWIN S. SHORTESS has joined WACLINE, INC., of Dayton, Ohio, as general manager of the meter division. He was director and administrative engineer at Hickok Electrical Instrument Co.

* * *

DONALD W. COOK has been promoted to director of the transducer division of CONSOLIDATED ELECTRO-DYNAMICS CORP., of Pasadena, Calif. He was previously assistant director of the analytical and control division.

* * *

ALFRED R. IVERSON is now sales engineer for DYNASALES COMPANY, Los Angeles, which represents several major instrument companies in the Southwest.

* * *

ALBERT VANDERHOOF has been promoted to sales manager of TECHNOLOGY INSTRUMENT CORPORATION's Illinois company. He was formerly eastern regional sales manager at TIC's home office in Acton, Mass., and assistant sales manager of TIC's subsidiary, ACTON LABORATORIES, INC.

* * *

CURTIS M. LEE has joined WYLE MANUFACTURING CORP., El Segundo, Calif., as chief engineer in charge of all phases of product design and engineering. Formerly, he was assistant manager of new product research and development for Rheem Manufacturing Co.

FOR FAST, SIMPLIFIED TEMPERATURE MEASUREMENTS . .

The RESCON
THERMAL TEST SET

A compact, portable unit for obtaining temperature measurements in electronic equipment — from the individual component to the package itself. Applications include: transistors, diodes, tubes, transformers, micro-miniature circuits, etc.

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ELECTRONICS CORPORATION
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Designers and Manufacturers of Electronic Test Equipment

Equipment Sales Elects; Other News of Sales Reps

Election of Angus MacArthur as president has been announced by Equipment Sales Company, New Haven, manufacturers agent for New England and eastern New York for such environmental test equipment manufacturers as MB Electronics and Avco Research and Advanced Development division.

At the same time, James Barry, who will manage Equipment Sales' branch office in Pittsfield, Mass., moved up as a vice president of the firm, and Robert J. Graeff, manager of the Danvers, Mass., office, became secretary-treasurer.

For representation in Missouri, southern Illinois, northern Oklahome, Kansas and Iowa, LAMBERT ENGINEERING COMPANY's Research and Testing Laboratory, St. Louis, Mo., has selected *Thunderbird Engineering Sales and Services, Inc.* Thunderbird's main office is in Wichita, Kan.

Hugh Marsland and Company, 6699 Lincoln Ave., Chicago, is TENNEY ENGINEERING, INC.'s, new representative for environmental equipment in Illinois, Indiana, Wisconsin, Iowa, Minnesota and western Kentucky. Marsland has branches in Indianapolis and Minneapolis. *Mel Sales Ltd.*, with head offices in Toronto and a branch in Montreal, has been named by Tenney as representative in Canada.

BORG-WARNER CONTROLS, Santa Ana, Calif., has also designated Midwestern and Canadian representation. *Midwest Electronic Sales*, Chicago, will provide sales and service in Illinois and Wisconsin, while *Tellurometer Canada, Ltd., of Ottawa*, will handle the complete Borg-Warner line in Canada.

Appointment of *Refrigeration Engineering Company*, 1781 Broadway, Seattle 22, Wash., as authorized representative in Washington has been announced by CONRAD, INC., Holland, Mich., manufacturer of environmental test chambers.

CINCINNATI SUB-ZERO PRODUCTS, Cincinnati, has appointed *Schafer Engineering Co.*, 9000 Livernois, Detroit, as Michigan rep for its low temperature industrial chilling machines and environmental test equipment.

Environmental test chambers and low temperature freezers of WEBBER MANUFACTURING CO., INC., Indianapolis, are being sold in California by *Egloff & Graper, Inc.*, 1798 Industrial Way, Los Angeles.

Brogan Associates, Inc., Long Island electronic manufacturers' rep, have moved to larger quarters at 220 Jericho Turnpike, Mineola, N. Y. The firm covers New England, New York and New Jersey.

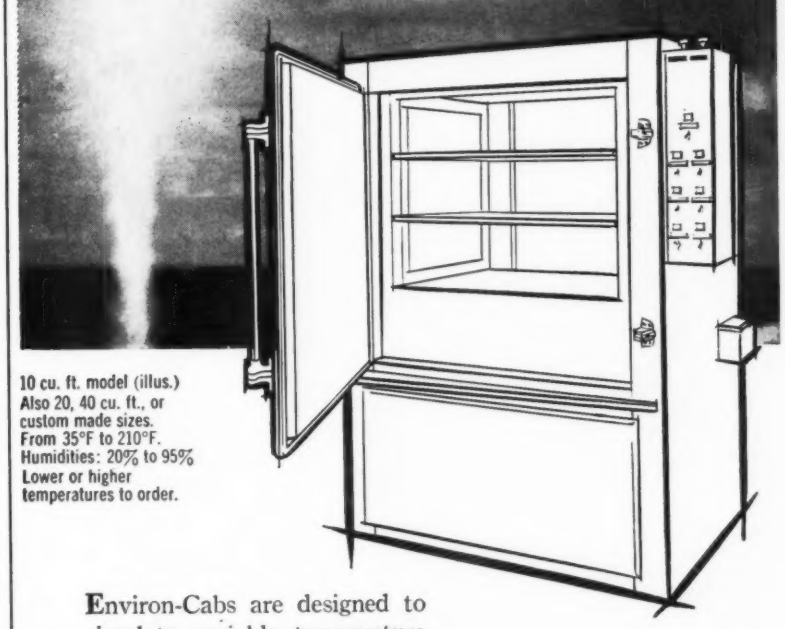
The Rucker Company, with headquarters at 4700 San Pablo Ave., Oakland, Calif., has been appointed exclusive factory rep and stocking distributor by the Industrial division of *MOOG SERVOCONTROLS, INC.*, for western states, Alaska and Hawaii.

PRODUCT

RELIABILITY INCREASED

when test procedures include

LABLINE-HUDSON BAY ENVIRON-CABS



10 cu. ft. model (illus.) Also 20, 40 cu. ft., or custom made sizes. From 35°F to 210°F. Humidities: 20% to 95% Lower or higher temperatures to order.

Environ-Cabs are designed to simulate variable temperature and humidity conditions encountered in JAN & MIL specifications. Suitable in plant and laboratory for testing metals, electrical and electronic components and assemblies, chemicals, paints, plastics, rubber, preservatives, packaging, protective coatings, etc.

Recorders, controllers, programmers are available. Mail coupon today.

Dept. N.

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Ask your dealer or write today for Bulletin 31.5-N

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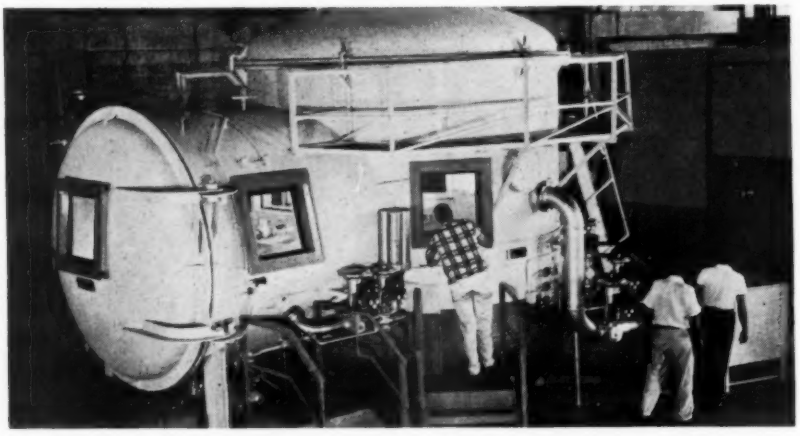
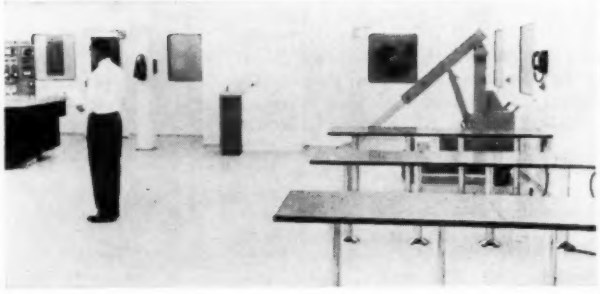
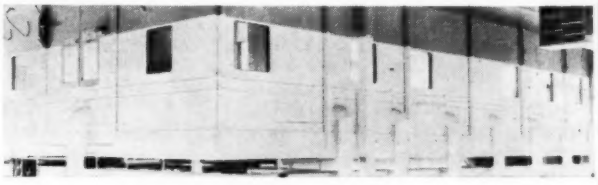


MERCURY POD—At Cape Canaveral, Fla., Project Mercury astronauts have this high altitude simulator (left) manufactured by **Tenney Engineering, Inc.**, Union, N. J., in which to acclimate themselves to space. Their capsule is lowered into a big, kettle-like section from the top, cutting them off from Earth except for an umbilical cord with oxygen lines, intercom and test control wires. The chamber "rises" to 225,000 feet, with dive rates to 50,000 feet a minute. The left section is a safety lock. **(For more info circle EQ RSC A.)**

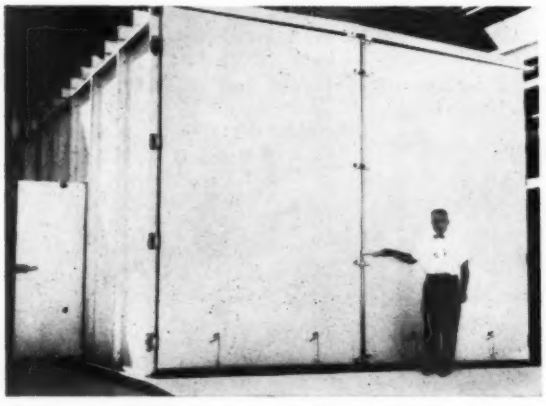
FOR BIG WHEELS AND SMALL—This new test chamber (below) by **Horkey-Moore Associates,** Torrance, Calif., is designed to test anything in the way of ground support equipment on wheels. Shown at the chamber entrance is an ammonia servicing trailer being made by H-M for the GAM-77 Hound Dog air-to-surface missile. **(For more info circle EQ RSC B.)**



ULTRA-CLEAN THROUGH—Inside (above) and out (below) views of the new, prefab clean rooms by **General Acoustics Corp.,** Los Angeles. This one is at Hughes Aircraft, El Segundo, for assembly, test and rework of Polaris equipment. Modular unit package includes everything from utilities to air-locks. **(For more info circle EQ RSC D.)**



DO-IT-YOURSELF—Bolt-together panels of polyurethane foam with a sheet metal skin (below) by **Wyle Manufacturing Corp.,** El Segundo, Calif., make possible temperature chambers of innumerable configurations which you or Wyle erect. The chambers can be adapted to such environments as humidity, sand-and-dust and fungus. This one, at Douglas, El Segundo, measures 14x24x11 feet. **(For more info circle EQ RSC C.)**



FOR SPACE TOURISTS ONLY—Mock-up (above) of a space test capsule was displayed by **The Garrett Corp.'s** AiResearch Manufacturing division at the Air Force Assn. convention several months ago. It goes into an environmental chamber or centrifuge. **(For more info circle EQ RSC E.)**

DIRT BUG

Dirt bugs lurk everywhere. They're the unseen enemy in many of the explosive failures of costly missiles. Microscopic dirt, in any material, component or assembly having surface contact with liquid or gaseous oxygen, nitrogen or helium, or with hydrocarbon fuel, must be removed to lower LOX impact sensitivity.

At the AEROTEST government-approved LOX cleaning facility, an extraordinary 15-step program insures "dirt-free" delivery of components involved in volatile liquid handling. Dirt above 100-200 microns is removed. Utilizing powerful microscopes, ultra-violet lights, and scrupulous cleansing operations, AEROTEST's LOX cleaning reaches the highest level of the art.

Write for specification No. 6E70-50 which includes complete details on LOX cleaning procedures. Technical and cost proposals for complete creative test programs submitted without obligation.

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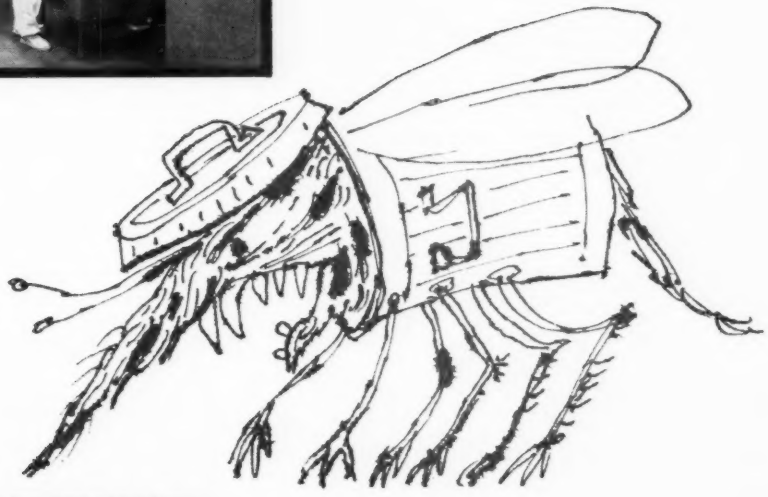
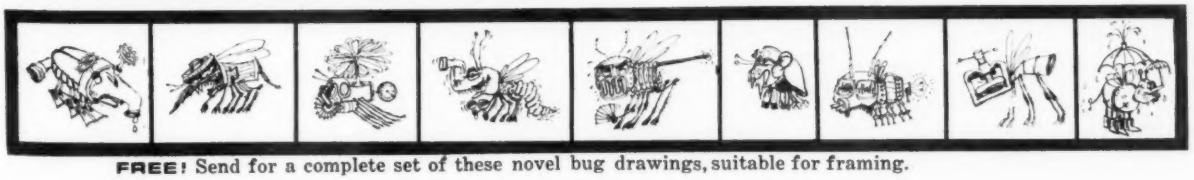


AEROTEST



FREE! Send for a complete set of these novel bug drawings, suitable for framing.

Sing a Song of Q!

"We never shun,"
the Vibra sang,
"The chance to jump for g!"
—and seldom soid
our waving sines
with noisy frequencies.

"We always tiff,"
the Sensi sang,
"In any field of gauss!
—and twist a wave
our strength to save
with justifiable loss!"

Ho! Impe-dance!
Ho! Resis-tance!
On the never rest
slopes of Q!
Ho! Reac-tance!
Ho! Capaci-tance!
On the sinister, sliding,
slippery, gliding,
descending
slopes
of
Q
!

"We never shall,"
the Poten sang,
"Avoid a crystal squeeze!
—and never roam
too far from ohm,
withal intemperate degrees!"

"We never fire,"
the Ampli sang,
"Until the lights of I's
—do swift enlarge
with coulombic charge
gaining a quantum size!"

Ho! Impe-dance!
Ho! Resis-tance!
On the never rest
slopes of Q!
Ho! Reac-tance!
Ho! Capaci-tance!
On the sinister, sliding,
slippery, gliding,
descending
slopes
of
Q
!

by Peter L. (Piezo) Shugart
Director of Advertising
Endevco Corporation

"We never quit,"
the TankCir sang,
"When currents run adrift!
—and seldom mil
as amperes will
when voltage gets a lift!"

"We always peek,"
the Signals sang,
"At spurious harmonies!
—and spike our track
with straight feedback
mulled with consummate E's!"

Ho! Impe-dance!
Ho! Resis-tance!
On the never rest
slopes of Q!
Ho! Reac-tance!
Ho! Capaci-tance!
On the sinister, sliding,
slippery, gliding,
descending
slopes
of
Q
!

Pete Shugart is a rarity as contributors to EQ go. His B.S. (Illinois) is in journalism, rather than engineering, with a specialization in chemistry. With that background, he tackled, more or less in this order, writing for a prominent Chicago pharmaceutical house, motion picture making in the Army, product development and technical communications for several California drug firms, advertising for a well-known electronics concern, the advertising directorship of a company making, among other things, petroleum refining installations, and, finally, Endevco Corporation, where he heads advertising, sales promotion and public relations. In between Pete composes—he says—classical and modern music for the piano, dashes off musical comedy lyrics, dabbles in oil (painting) and devotes his bachelorhood to enjoying life as much as possible. Madison Avenue also knows him as the author of a book, "How to Evaluate Your Industrial Advertising Dollar." Endevco is in Pasadena, Cal.

CONRAD Inc.

TEMP-RAC 19

HIGH-LOW TEMPERATURE TESTING WHEN & WHERE YOU WANT IT!

Testing small assemblies and components to military and government specifications is simple and convenient with Conrad's new Temp-Rac 19. Move it anywhere in your laboratory, any place on your production line. Temp-Rac 19 has a range of —90° to +300°F., 16" x 16" x 16" I.D. test area, and it's air cooled, requiring only electricity for operation. One or more of these compact chambers can give your facilities the flexibility that assures more efficient testing and production. Ask your Conrad representative to show you. Write today.

- 16"x16"x16" I.D., clear of coil and circulator.
- Occupies only 4 sq. ft. floor space — easy to move on heavy duty swivel casters supplied with chamber.
- Light recessed into chamber ceiling.
- Safety mesh for fan.
- Patented Conrad Cascade Refrigeration System.
- 220 volt, single phase, 60 cycle, 3-wire service.
- Optional features include view window in door, access ports, removable door with shelf assembly, terminal pads.

Introduced only a few months ago, the Conrad Temp-Rac 19 has won quick acceptance because of its wide application in production and testing. Conrad suggests placing orders early to assure delivery from stock.

CONRAD Inc.

HOLLAND MICHIGAN

Subsidiary, Crampton Mfg. Co. Grand Rapids, Michigan

by Robert L. Sutherland
Head, Mechanical Engineering Department
University of Wyoming

An Engineering Educator Looks at The Environment

A HISTORY OF ENVIRONMENTAL TESTING would yield many intriguing facts; perhaps such a study has already been made. Did the Wright brothers subject their flimsy machine to some sort of crude pre-flight testing to simulate, possibly, the vibration they expected to encounter? Were the builders of the railroad empire the first to employ environmental testing? Or was it the early pioneer, ingenious and resourceful, whose life and existence depended upon the reliability of the equipment that he himself, or a few other craftsmen, made?

Perhaps it was James Watt—Newton—Leonardo da Vinci —or Hero of Alexandria. Maybe some of the first applications of environmental testing could even be traced through times before Christ to Aristotle, Archimedes, or the ancient Egyptians and pyramid builders.

The Future Is Secure

In modern times, large scale environmental testing for industrial purposes probably began with the testing of automotive and aircraft engines in temperature-controlled chambers, although without doubt there were other instances of the testing of equipment under controlled-environment conditions between, say, 1900 and 1930. The tremendous advances in environmental engineering, however, have of course occurred within the past 15 years, hot on the heels of the Jet and Space Age.

There is little question as to the continued significance and importance of environmental engineering. Anyone who claims that environment and reliability will soon pass out of the picture is most certainly existing in a state of blissful complacency.

Engineers have long been concerned with reliability—to degrees varying, of course, with the circumstances, the product, the times and other conditions. The Space Age has simply propelled reliability problems and requirements to a new and much higher level. The theories and techniques of reliability evaluation and testing as developed by the missile industry will inevitably feed back into other branches of engineering to be adopted or adapted for the further improvement of a multitude of products in common use.

What is the role of engineering education in this new era? I would guess that the situation is similar in many, though not all, respects to engineering advancements of the past. As an example, when mass production techniques were introduced into manufacturing, there were probably many questions asked: How would this new concept be advanced? What were the applications and limitations? How could engineers be trained? Of what value would engineering education in the colleges and universities be to the new field? And, like other changes that have come along, including the present one, the answer is the same: Scientific and engineering knowledge is developed, advanced and disseminated through the joint efforts of industry and education.

Industry and University

Depending upon the particular situation, industry may handle a greater proportion than the university, or vice versa. The problem of advancing environmental engineering is no exception. It represents a case in which industry will probably carry a larger share of the development than will the universities, but nevertheless the universities can help greatly, because many of the problems revert to engineering fundamentals.

In support of the contention that the problems of environmental engineering, in general, do depend upon basic engineering and physics, and that they are not simply technical institute-type "practical problems," let us consider the circumstances and phenomena involved.

Engineering Fundamentals

¶Suppose the environment is such that corrosion is the result; then properties of materials, humidity control, surface treatment, or perhaps the electromotive series may hold the explanation.

¶If a failure is caused (or sought) by sound energy, the theory of acoustics must be consulted.

¶When temperature is involved, any one or more of many principles must be understood: heat transfer, co-

Bob Sutherland, who became head of his department at the University of Wyoming, in Laramie, last July 1, has had long acquaintance with The Environment. The report, "Fatigue Machines for Low Temperatures," which Prof. Sutherland co-authored, won the 1952 Richard L. Templin award of the American Society for Testing Materials. An alumnus (both B. S. and M. S.) of the University of Illinois, he taught mechanical engineering for a decade at the State University of Iowa before joining UW in 1958. In private industry, he has been senior engineer in Aeronca Aircraft's research department and he has held positions with Buick, Borg-Warner and Firestone Tire. Prof. Sutherland is a member of Sigma Xi, Pi Tau Sigma, Sigma Tau, ASME and SAE, among other organizations. His book, "Engineering Systems Analysis," was published in 1958.

Sutherland

a compact, pneumatically controlled shock test machine

for production testing of small components

Avco's new component Shock Test Machine SM-005 is a compact, pneumatically controlled and actuated device that reproduces shocks such as those encountered in missile flight. Used for production testing, it produces the widest variety of pulse shapes available with unmatched repeatability.

SM-005 does not depend entirely on gravity to obtain desired terminal velocity, but is actuated by a pneumatic cylinder. Shock pulse changeover from one g level to another can be rapidly accomplished by simply adjusting air pressure and/or carriage height setting. Extremely high impact velocities can be achieved. With a drop height of 8 inches and an air pressure setting of 80 psi, SM-005 develops an impact velocity of 192 in./sec., equivalent to a 4-foot free-fall.

Easy to install, simple and safe to operate, Avco's SM-005 offers these other advantages:

- **Provides sawtooth, triangular and half-sine pulses as required.**
- **Meets rigid testing specs for qualifications testing of ICBM electronic components.**
- **Produces 1500g and 3000g pulses required by transistor test specs.**
- **Switch setting allows automatic recycling of machine up to 10 times.**
- **Trouble-free operation of brake/release mechanism assured because it contains no moving parts.**
- **Operator works at bench height—no stooping to replace test specimen.**
- **Machine is highly portable—need not be lag-bolted to floor.**
- **Tests specimen loads up to 30 pounds.**

SM-005 is one of a family of Avco-designed shock test machines. It fills the need of the component manufacturer for a completely reliable testing machine which will handle small loads such as transistors, relays and micromodules. It also provides the simple operation and high degree of repeatability required by production organizations.

For more information contact your nearest representative—offices located throughout the U.S. and the world. Or write to: *Industrial Marketing Department, Research and Advanced Development Division, Avco Corporation, Wilmington, Mass.*

Avco
Research & Advanced Development

efficient of expansion, properties of materials and so forth.

¶If a component or accessory is subjected to shaking, vibration theory will, of course, enter the picture.

¶The application of shock brings in mechanics, energy transfer and dissipation, elasticity, etc.

¶Perhaps a functional failure caused by stray fields is involved; then the engineer must look to field theory and other basic priciples of physics and electricity for an answer.

Solid Background Required

Where can one find a better laboratory for application, observation and demonstration of fundamentals and for sharpening one's understanding of these fundamentals? Certainly the design and application of reliable test equipment and realistic tests to evaluate components correctly under a variety of environmental circumstances must require a solid background of education and knowledge in disciplines such as those suggested above.

Accepting the premise that the universities can be of assistance, the question arises as to what extent they should participate in environmental engineering beyond the requirement that the engineering curriculum should give a thorough training in fundamentals. As is often the case, there are two possible extremes to the answer—"none" or "all the way."

It is most likely, and understandably so, that many small colleges and universities may never get into the environmental picture at all as regards curricula offerings beyond fundamental science and engineering courses. On the other hand, at larger institutions environmental engineering may be emphasized to the point of granting a special degree, but this is improbable and out of line with the philosophy that the primary objective of engineering education is the attainment of fundamentals.

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LOW-COST
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Complete price
(No extras to buy)
CONTROLS HUMIDITY
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(Depends on Dry Bulb Temperature)
DRY BULB:
Ambient to 156° F. within ± 1° F.
Compact, Complete, fully automatic Controlled R.H. offered at low cost. Inverted Pyrex Jar (16"Dx12"H used as work chamber) placed on Stainless Steel Cabinet housing Controls, Motor and Blower. Guaranteed accurate and stable controlled humidity.
MECHANICAL
ANNULAR AIR FLOW
FULL ACCESSIBILITY
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IDEAL FOR MANY MIL, JAN, AND ASTM TESTS
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Wide Latitude for Teaching

In between the extremes, however, there is a latitude for utilizing the problems of environmental engineering in engineering education, and for familiarization of the student with the techniques and progress in that area. Vibration, vibration problems, fixture design problems and similar areas probably are most easily adapted to the present framework of undergraduate engineering courses. In the graduate area, of course, many excellent problems suitable for study and research may be introduced, encompassing a greater proportion of the environmental spectrum.

Although it is unrealistic to expect all, or even many, to do so, there is a need for some engineering colleges to take an active part in environmental engineering by means of basic equipment. This should include at the minimum an electrodynamic shaker unit of reasonable capacity and a small atmospheric chamber with provisions for simulating a variety of temperature, pressure, and humidity conditions. Such equipment would be used for demonstration and experimentation in undergraduate classes and for research work at the graduate and faculty level.

What are the benefits to be realized from such programs in environmental engineering on the part of some universities? First, these institutions will become a source of supply of engineers with background training in environmental engineering who are so critically needed in industry. Second, research coming from graduate level and faculty investigations may contribute valuable data and theory regarding environmental engineering problems, while at the same time giving the graduate students excellent experience. At the same time, the industries which are hard pressed by high priority assignments in the missile programs can be relieved of some of the annoying problems which they do not have time to solve by research on their own.

Campus-Industry Coordination

Such university programs will, however, require cooperation with industry at various stages. In order to get these into operation, the universities will probably need aid and advice from the equipment manufacturers in setting up the facilities. Moreover, maximum benefit requires good and continuous communication between industry and its problems and the universities and their problems.

As an example of what is possible, the Department of Mechanical Engineering in the College of Engineering, University of Wyoming, has been fortunate in making plans for setting up environmental equipment in its new laboratory. Some assistance from vibration equipment manufacturers has already been received, in the form of accessory equipment as well as training manuals and other aids. Also, initial contacts with environmental testing laboratories have been established by summer employment of faculty, and the problems and needs of both industry and education are mutually understood.

While some of the applications encountered in environmental engineering are seemingly unique to the missile industry, it should not be forgotten that the solution to any problems which pierce the frontiers of unknown regions of engineering endeavor almost always open the way to new avenues of progress and improvement in other directions.

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Unified vibration systems and instrumentation

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VELOCITY
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- Simultaneous Readout of Acceleration, Displacement and Velocity.
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- Sensitivity Dial Calibrated directly in accelerometer sensitivity automatically normalizes all outputs when dial is set to accelerometer sensitvity.
- Logarithmic Meter Scale provides equal accuracy at any scale reading. Reduces range switching by 50%. Mirror scale.
- Driven shield input cable allows using 25 ft. cable with negligible signal loss.
- High Input Impedance eliminates need for external cathode follower.
- Available with and without integral meter and rack mounted in single or triple units.

UNHOLTZ-DICKIE CORPORATION

2994 Whitney Avenue, Hamden 18, Conn.

Workmanship Vibration

To guard against faulty assembly of its TV sets, Philco subjects them to vibration tests on the production line and turns them on for a quick check of reliability by observing the screen. This relatively inexpensive means of testing, known as workmanship vibration, has been adopted for the company's military electronic equipment, too, with excellent results. Operating the equipment during vibration is more important to uncovering possible intermittent trouble than before and after-vibration operation.

by Art Shafran

Project Engineer
Philco Corporation

WORKMANSHIP VIBRATION IS AN UNUSUAL and inexpensive method of insuring against equipment failure at some crucial moment. It is a relatively simple procedure, remarkably inexpensive and, once established, not time consuming. Materials can be used over and over again.

The key is vibration while the test objects are operating.

To induce workmanship vibration in television sets is not too difficult; a set weighs only about 50 pounds. Military electronic equipment is something else again. Weighing hundreds or even thousands of pounds, especially when many equipments are involved, they require a major test program. This discussion deals with a method for inducing workmanship vibration in equipments weighing 300 to 1,000 pounds, and with a way of determining criteria adequate for an effective test.

Under consideration are racks of chassis and associated hardware standing seven feet, with a two-foot square cross section. Some are resting on concrete, some on floor tile and others on wheels. The racks cannot be moved from their assembled position, and so they must be workmanship vibrated wherever they are.

Conventional Equipment Impractical

These factors, plus operation during vibration, make the use of normal vibration equipment impractical, if not impossible. Such equipment is generally too heavy and bulky to be moved to the rack.

A vibration source must be found, however. Three aspects influence its choice for workmanship vibration purposes: (1) the desired vibration level, (2) where to monitor the vibration and (3) duration of the vibration.

In considering the vibration level, the equipment to be workmanship tested must be evaluated as to its components. Resistors, capacitors, coils, transistors, tubes and similar parts require levels which may differ to the extent of exceeding design limits.

At Philco's Western Development Laboratories, tests were conducted on representative racks of welded steel construction. Chassis were mounted to the rack front rail and, in some cases, to a rear rail. Most of the chassis also were supported by slides permitting removal for maintenance.

Pickups on Frame and Components

Vibration pickups were mounted on components in chassis at the top, center and bottom of the racks, and on the rack frame top, center and bottom. Accelerations of 4 and of .5 gs at 60 cps were impressed on the racks. Transmissibility from the frame to the components varied from 2 to .7.

At this level, the maximum acceleration a component may experience is 8 gs, the minimum, .4. Tests results indicated that for the equipment under consideration component and wire lead failure resulted from raising vibration acceleration above 4 gs on the rack. It was due to repeated stresses exceeding allowable design stresses.

This indicated that the poor workmanship range was at or below 4 gs at 60 cps impressed on the rack frame. The component vibration range was 8 to .4 gs, and the frequency varied from 60 to 180 cps.

It also appeared that most of the components in the chassis exhibited a natural frequency above 500 cps, so to

---

Art Shafran is another New Yorker who went West. A graduate of Polytechnic Institute of Brooklyn, class of 1951, with a mechanical engineering degree, his early working experience was with the well-known Bulova research and development lab and with Emerson Radio. Later he joined Farrand Optical Company. Currently Art is with Philco's Government and Industrial division, Western Development Laboratories, in Palo Alto, Calif. He makes his home in Mt. View, Calif.

Shafran

help reduce most component resonance the frequency impressed on the racks was kept below 500 cps. The test also indicated that components and wire leads were more likely to show poor workmanship at less than 100 cps, where component and wire lead deflection is greater and acceleration is sustained over a longer period.

With greater component deflection, wire leads are more likely to reach and exceed the flexure endurance limit. Since fatigue failure is a function of the endurance limit, it was reasonable to expect more poor workmanship to be exposed at the lower frequencies. The major difficulty lay in determining the vibration level so as not to cause failure other than poor workmanship in a wide variety of circuitry. The more complex the equipment, the more detailed and complete the preliminary test had to be. A certain amount of judgment was used in setting the vibration level, since it was impractical to test and set limits for all of the circuitry.

Where to Monitor

Consideration of where to monitor the rack vibration level to insure that the circuitry be vibrated within the limits set revealed three alternatives: (1) the rack frame, (2) chassis front panels connected to the frame and (3) components in the chassis—the parts really of concern.

Placing vibration pickups on the circuitry would, in essence, have indicated the vibration of direct concern, but the complexity of implementing this test warranted using another suitable but less involved area. Either of the two alternatives that remained were suitable for this purpose, with the front panels perhaps being the better, since they were the closest link in the chain of vibration elements ending in the components. Since the chassis were mounted to the rack frame by their front panels, they were the most reasonable surfaces with which to look for vibration levels. The chassis components were of interest, but not the rack proper.

Time remained the element which would define the workmanship vibration test. It seemed, at first, best to vibrate the racks for as long as possible, but, no matter how perfect, any assembly will fail in time under repeated stresses. The point was to choose an interval which was consistent with the equipment. For ruggedly designed and assembled equipment, 15 to 25 minutes seemed reasonable, for equipment which the designer and assemblers did not have time to redesign and assemble out of the prototype stage, five minutes. For the equipment at Philco WDL an interval of 15 minutes was chosen. (The Philco equipment has been delivered and is operating satisfactorily with a high degree of reliability. Therefore, it can be assumed that the interval chosen was substantially adequate.)

Conditions Chosen

The resulting vibration and monitoring for all the racks was as follows:

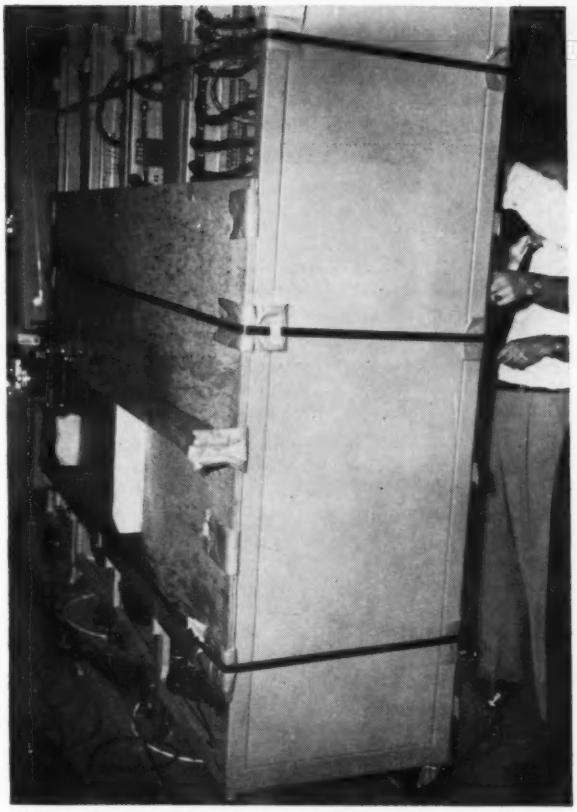
¶ Frequency—60 cps.

¶ Acceleration (0 to peak)—4 gs maximum and .5 gs minimum.

¶ Time—15 minutes.

¶ Monitoring—vibration pickups mounted on the front panel (top, center and bottom of each rack). Three monitoring points on each rack.

With vibration level and time for a workmanship test determined, it was necessary to provide a vibration source which complied with the level and time requirements and weight and especially location criteria. The maximum weight of each rack was 1,000 pounds, the minimum, 300. To speed the test, several racks were vibrated together. A maximum number, or rack module, was chosen



Workmanship vibration test set-up at Philco's Western labs consists of ¾" plywood fixture board, tied to racks with steel shipping straps, and a vibrator, of the type used to shake concrete forms, mounted on a reinforcing two-by-four beam. Padding under the straps and brown wrapping paper between racks protect the finish.

from which the maximum energy level was determined. Considering the weight and geographical location of the racks, and method for holding racks together while vibrating, it was decided not to shake more than four racks together. This meant a possible 4,000-pound or 1,200-pound load. From the equation:

$$S = \frac{386\ (g)}{(2\ pi\ f)\,z}$$

where S is displacement (inches), g is acceleration (g units) and f is frequency (cps), the displacement for the maximum condition of 4 gs at 60 cps equals $S = \frac{386\ (4)}{(2\ pi\ 60)z}$.

S = .011 inches, and the horsepower required equals:

$$\text{H.P. (maximum)} = \frac{.011\ (4000)\ (60)}{(550)\ \ (2)} = 2.4\ \text{H.P.}$$

$$\text{H.P. (minimum)} = \frac{.011\ (1200)\ (60)}{(550)\ \ (2)} = .7\ \text{H.P.}$$

Several types of vibration sources were investigated. The pulsating magnet type was chosen on the basis that it provided a completely portable unit, the displacement was easily made variable, and it could be run from a 60 cycle, 115 volt line, making possible the use of more than one vibrator when they were pulsed from the same 60-cycle source. A vibrator was chosen which was designed for vibratory material handling equipment, specifically for moving parts on an assembly line, and also very widely

used for shaking concrete forms to remove pockets of air in concrete. It operated at 60 cps and provided 1.34 horsepower. Two vibrators provided 2.68 horsepower which met the maximum energy needed for four racks. A controller for the vibrator allowed stepping down the displacement. In this way the lower limit of the required horsepower was satisfied as well as the upper limit.

Several vibrators are available for a wide range of equipment—.20, .37, .80, 1.34, 2.70, and 3.35 horsepower units in various combinations. A convenient aspect of this type of design setup is the wide versatility of vibration levels and the opportunity of switching vibrators until the correct combination is obtained. Generally energy calculations were about 10 percent under the level actually needed. One reason for this was that the analysis did not account for the surface friction between the bottom of the rack and the surface on which it rested, and the friction between each rack.

Final Steps in Setting Up

With the vibration source chosen, means had to be provided for holding the racks together and mounting the vibrators. For holding, the racks were tied together with a fixture board to which the vibrators were mounted. Steel shipping straps, .020" thick and .75" wide, banded the racks together with ¾" reinforced plywood.

The plywood, mounted to the back of the racks, ran the width of the racks and was 4' high. For four racks the plywood was 4' x 4' x ¾", for three racks 3' x 4' x ¾", for two racks 2' x 4' x ¾", and for one rack 1' x 4' x ¾". Two-by-fours reinforced the plywood and also provided a mount surface for the vibrators. Tuflex padding material was used under the shipping straps to protect the racks, and also between the plywood and the racks. A sheet of heavy brown paper was slipped in between each rack to protect the sides.

Any doubt as to the holding strength of the shipping straps was quickly dispelled. In many cases two straps were sufficient. The plywood fixture received a good deal of stiffness from the 2" x 4" wooden reinforcing members.

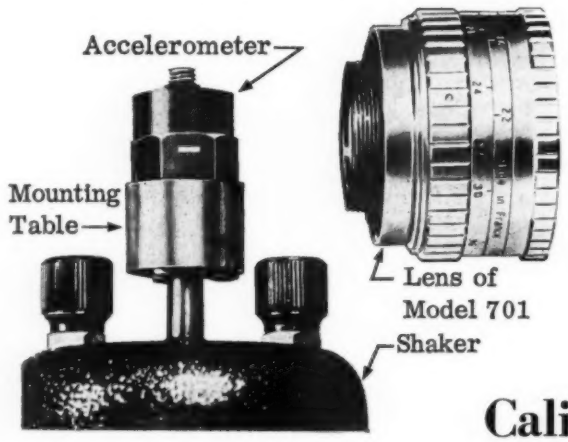
When the test was finished, a pair of shears cut the straps and released the plywood fixture for use on another four racks. Several fixtures were fabricated so that they could handle any number of racks up to four, and could be replaced if damaged. The shipping straps were the only items which were not reusable.

A hand truck with several models of vibrators, control boxes, portable vibration equipment and padding with brown paper, and a shipping-strap cart were all that were necessary to ready the racks for workmanship vibration. Set-up time averaged about 20 minutes, and breakdown about five. The total time, including vibration, was about 40 minutes for four racks, so that for 100 racks approximately 20 hours were needed. The cost of materials for this operation ran hardly over $200.

Recommended Procedure

The workmanship vibration test performed on 100 racks at the Philco laboratories supplied valuable information for future tests. The following is a recommended approach when attempting workmanship vibration for military electronic or similar equipment:

1. Determine vibration level based on pretesting representative equipment. Several levels may be required for a wide range of component types appearing in the chassis.
2. Determine number of equipments to be tested together. This can be called the workmanship vibration modules.
3. Determine where vibration monitoring will best represent circuitry vibration.
4. Determine energy required to vibrate the largest and the smallest module.
5. Determine vibrator, fixtures and holding method for test.



OPTRON Model 701 DISPLACEMENT FOLLOWER

Measures Vibration

To measure the displacement of an accelerometer, simply focus the spot of light from the Optron Model 701 on the edge of the accelerometer. It's that easy! **Frequency response**: Static to 7 kc. **Resolution** 12 micro inches.

Calibrates Accelerometers

Optron Model 701's interchangeable lenses provide five ranges: .050", .100", ½", 1" and 2" full scale. A heavy seismic stand provides isolation from the floor from 2 cps up. Model 701 never requires jigs or fixtures clamped to the work—it never makes contact with the specimen. It works on any material regardless of size, shape or composition—and it works in daylight!

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Environments in Use

Taped Shake Test Program Assures Repeatability

The Problem: When Ampex set up operational assurance testing (actually a production environmental test) for each and every MR-100 missile recorder it manufactures (EQ, July '60, Pg. 36), it wanted to be sure of identical vibration test programs. Also, a record of each test result was to go with its respective unit.

THE SOLUTION: To achieve its goal, Ampex turned to its own product, a magnetic tape recorder, to program a shaker.

A tape-programmed shaker, it says, recreates vibration with the same reliability as a tape recorder, a near perfect memory device, reproduces a taped symphony. No matter how complex the music or signal, the only worry is volume setting and fidelity of the amplifier-speaker system. Within the limits of frequency response, dynamic range and recording time, the tape can record and play back any program of electrical signals.

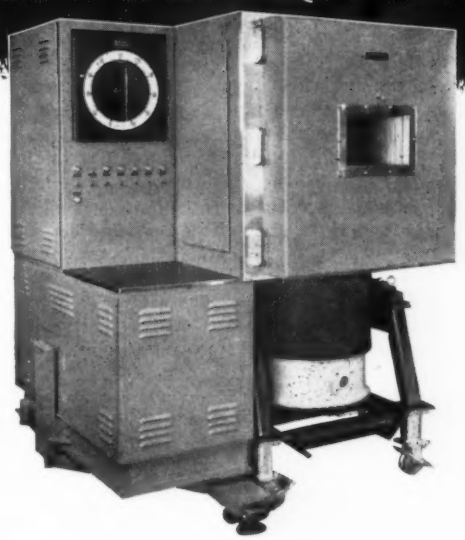
Frequency Modulation carrier recording is generally used to program vibration tests. This technique reproduces amplitude accurately and is not subject to dropouts (instantaneous lapses or reduction in signal level). Vibration amplitude can be reproduced with an accuracy of better than 1 per cent of full scale on a recorder whose signal-to-noise ratio, is as high as 50 decibels. Total program-time on a conventional recorder with 10-½ inch reels is 45 minutes at 15 inches-per-second speed, producing 2500-cycle response. At 30 ips, 22-1/2 minutes can be provided with a 5,000-cycle response. A tape loop or bi-directional automatic reversing recorder can repeat indefinitely, providing very extended endurance tests when needed.

The vibration-programming tape recorder needs its power amplifier and transducer just as the audio tape recorder requires amplifier and speaker to reproduce music satisfactorily. In a vibration test system, an electronic amplifier of extreme power is necessary. The concept of level response, basic to high-fidelity music, is also present in the shaker system.

The tape recorder makes it possible to save, repeat, and

READY FOR A PROGRAMMED SHAKE: In the Ampex environmental lab, a MR-100 missile recorder is mounted on a vibrator's test fixture while an engineer adjusts the vibration meter. At the right is the Ampex FR-1100 recorder which programs the vibration test.

COMBINED ENVIRONMENT TESTING { vibration temperature altitude humidity



- temperature, altitude, humidity ranges to your requirements
- vibration in any plane
- may be designed to accommodate existing vibration equipment
- may be used with or without vibration

Murphy & Miller Series LTUV Environmental Test Cabinets are complete, self-contained units incorporating advanced design and operating features to provide users with an efficient, trouble-free test medium. The LTUV Cabinet may be used with or without the vibrating unit. Stainless steel test space, indicating type controls and optional equipment like cabinet self-elevation, recorder controllers, programmers with automatic percentage capacity control make these Cabinets the preferred test units used by discriminating researchers.

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copy any test program it is possible to devise. Thus the effort expended on arriving at a meaningful program need not be repeated for subsequent tests. A reel of tape can preserve the whole effort, and even on a sine-wave sweep, programming the shaker from magnetic tape can save manpower and insure uniformity of tests.

In simplified tests, the recorder can program a complex-wave test of the assembly, and a second recorder can record the resonant response of individual parts. Then after sufficient study, excitation by a sine-wave generator can possibly be substituted in subsequent tests of individual parts to produce the same response as before.

In the ultimate case, a central programming source can make component-testing tapes and distribute them to a whole chain of subcontractors. Provided each subcontractor is equipped with suitable shaker equipment, he can run specified shake tests. Calibration of the individual shakers is a relatively straightforward process using standard signals at the beginning of each tape.

Tape for a Magnetic Tape Recorder

Ampex uses its FR-1100 recorder/reproducer to program tests on its mobile, airborne and outer space magnetic tape recorders. Complete records of performance characteristics derived from the tests are made on an Ampex Model 601 two-track laboratory recorder.

The MR-100 operational assurance vibration test requires mounting the entire recorder on the test fixture with the vibration cycle conducted for each of three mutually perpendicular axes. As programmed on the FR-1100, a voice track announces the frequency in use while a second track feeds the stated frequency to the vibrator. The amplitude of vibration is manually controlled by an operator to induce accelerations. At a sweep rate of one minute per range, vibration is applied in the following frequency ranges: 20 to 60 cps, 60 to 120 cps, 120 to 250 cps, 250 to 500 cps and 500 to 1000 cps. Each sweep is repeated three times, one for each axis.

A maximum force of 5 Gs from 20 to 1000 cps is specified for the vibration cycle conducted in the first axis; 5 Gs from 20 to 800 cps and 4.5 Gs from 800 to 1000 cps in the second. In the third axis, three forces are specified: 5 Gs from 20 to 600 cps, 4.5 Gs from 600 to 700 cps, and 5 Gs from 700 to 1000 cps.

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Ultra-High Vacuum Helps Refine Silicon

A few of a battery of special, very high vacuum chambers built by the F. J. Stokes Corporation for refining silicon on a commercial scale to just about absolute purity. The chambers are used by Merck & Company in the floating zone refining process.

The Problem: Merck & Co., Inc.'s Electronic Chemicals division sought an effective and economical way of refining silicon for semiconductors on a commercial scale to a degree of purity approaching the theoretical limit —an impurity content of one part in 10 billion.

THE SOLUTION: Banks of specially-designed vacuum chambers were built for Merck by F. J. Stokes Corporation, Philadelphia, to maintain uniform ultra-high vacuum conditions continuously for a technique known as floating zone refining. The refining required extremely low pressures, 1 x 10^{-5} mm Hg, the equivalent of one ten-millionth of an atmosphere.

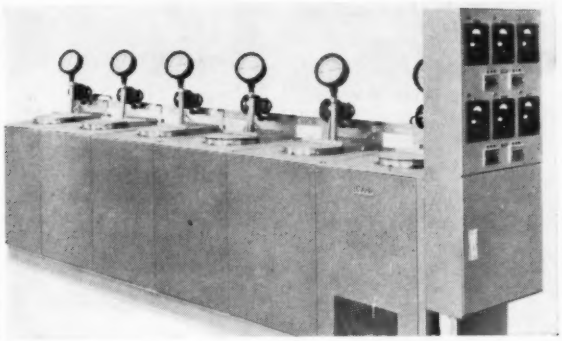
In ordinary melting techniques the silicon may pick up unwanted impurities, such as boron and oxygen, from the crucible material itself. In floating zone refining, an ingot of silicon is supported between chucks, and a narrow zone is melted by induction heating from a radio frequency generator. Moving the r.f. coil along the ingot moves the molten zone the length of the ingot, carrying with it impurities that are slower to recrystallize than pure silicon.

Volatilization of Impurities

When the zone refining is carried out in a vacuum, many undesirable impurities, such as arsenic and phosphorus, can be removed from the silicon purely by volatilization. Another major advantage of vacuum is that it is fundamentally purer than any inert gas, and a lot cheaper.

Since Merck is in full-scale production of several forms of ultra-pure silicon, the Stokes vacuum chambers are kept busy around the clock, seven days a week. Refining cycles last several hours.

Space Age Production Depends on Low Temperatures



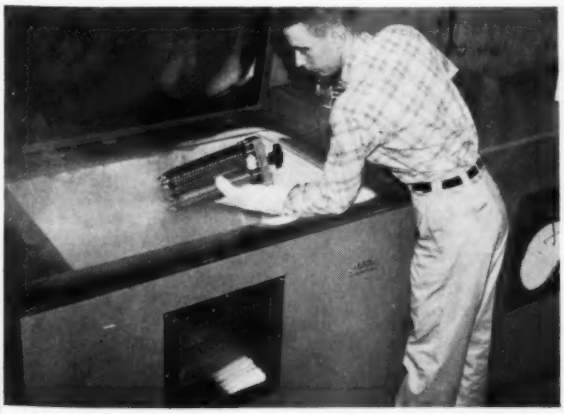
Battery of liquid baths at Mason-Neilan for calibrating recording and indicating instruments in temperatures ranging from —40° to +1,000° F. (For more info circle EQ RSC H.)

The low temperature techniques which even the general public has come to associate with the extreme conditions required for environmental testing are finding wide application in development and production work. Here are two examples of a major environment in use from the files of Harris Manufacturing Co., Cambridge, Mass., a leading company in the refrigeration field.

The space age demands unhampered functioning of controls and freedom from distortion or weakening of materials at temperatures achieved only in the laboratory a decade or two ago. Today, low temperature refrigeration, mechanically produced, dependably maintains sub-zero temperatures for testing controls and materials under extreme use conditions.

Such installations are commonly achieving temperatures to —200° F with still lower temperatures feasible and within the limits of economy. Other units, some integral with the low temperature chambers, provide a temperature range from zero up to +1000° F or more.

Electro-Switch Corp., Weymouth, Mass., has been testing complex rotary switches at —100° F in a Harris Model 10L-A2-10, 10 cu. ft. refrigeration unit, for three years. The accuracy of this environmental test has proved itself in practice, and according to Electro-Switch officials, the unit requires only normal maintenance despite heavy and consistent use.



Francis P. Almond, of Electro-Switch Corp., lifts rotary switches from 10-cubic-foot environmental cabinet by Harris Manufacturing Co. after low temperature test at —100° F.

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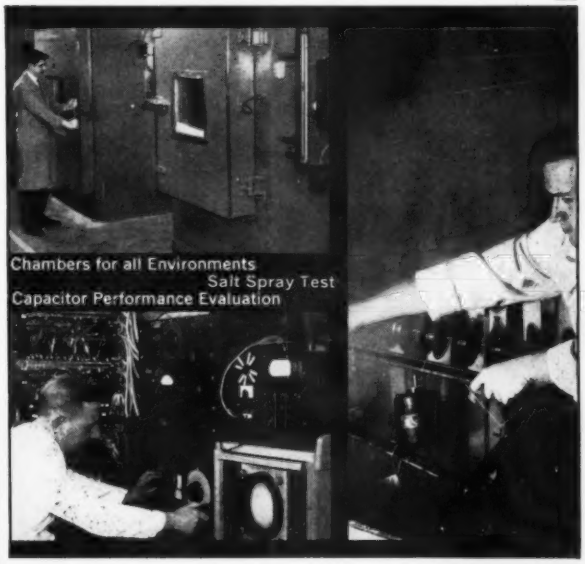
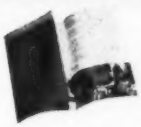
Complete facilities in the fields of chemistry; metals chemistry; metallurgy; physical testing of materials; engineering analysis of mechanical, electromechanical and electronic devices; site inspection; package testing; psychometrics and certification services for product quality control.

22





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Environmental Want Ads

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Deadline for April, 1961, issue is Feb. 10, 1961. Send order, copy, payment and all inquiries to Environmental Want Ads, Environmental Quarterly, 252-46 Leeds Rd., Little Neck 62, N.Y.

For free "Situation Wanted" ad give only following information in this order: Job title (two permitted), age (if desired), degrees, recent experience, salary desired, where you prefer to work and name and address. (Last two will be withheld if reply code is used.)

SITUATIONS AVAILABLE

Piezo-Electric Accelerometer Engineer

Excellent position for engineer experienced in accelerometers or ultra-sonic transducers.

Please phone BIgelow 4-7500 or send your resume to Mr. Paul Dempsey, Raytheon Company, Industrial Components Division, 55 Chapel Street, Newton, Massachusetts (suburban Boston).

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ENVMTL LAB SUPVR, BS/ME, facilities & instrmntn supvr, sal open, EQ#20.

ENVMTL LAB SUPVN, BS/EE, dir envmtl facilities, testg and evaltn. EQ #22.

ENVMTL LAB SUPVR, Qual assurance mgr, BS/EE, 9 yrs exp dir envmtl facilities, test, evaltn, mntnce. Sal open. EQ #23.

ENVMTL LAB SUPVR, BS/Phy, experienced, vib. spclst, desire less pop. area. EQ #24.

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WESTERN NEW YORK SALES Representatives desire additional lines of Environmental Test Equipment and Testing Service for territory. Ten years collective experience. Write: Paul F. Markstrom, Box 52, Grand Island, New York.

Attention Advertisers:

The next issue of Environmental Quarterly will be out in late March—before the IES industry-wide exposition. Please note the following deadlines:

Space reservations	**Feb. 1**
Classified and recuritment ads	**Feb. 10**
Complete plates due	**Feb. 20**

NEW PRODUCTS...

A "Reader Service Card" requiring no postage is bound into this issue for the convenience of those desiring additional information on new products, new literature (Page 43) and other announcements. It is keyed in the text as "EQ RSC."

SPOTLIGHT ON:

Dual Centrifuge

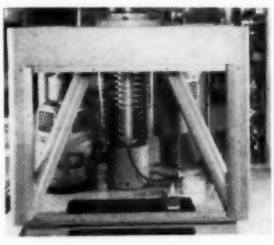
With the emergence of the centrifuge, or rotary accelerator, as a critical tool in component and subsystem reliability testing has come a demand for special units for varying size, weight, instrumentation and g-pound requirements, as well as different profiles of rise, dwell and decay times vs. acceleration.

Such a special unit is **Schaevitz Engineering's** dual centrifuge **Type DC-4**, which subjects test objects to an acceleration field while rotating them about a vertical axis transverse to the field. It consists of a small satellite table mounted on a large turntable, so arranged that the absolute angular velocity of the small turntable is controlled independently. Provisions are made for obtaining balance. The radial distance of the small turntable from the center of the main spindle is fixed.

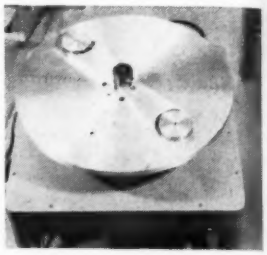
The DC-4 consists of a supporting framework and base, safety guard, rotating table mounted on a spindle supported in a pair of precision tapered roller bearings and an auxiliary table mounted in sealed precision ball bearings. Slip rings and brush assemblies are provided on the main and auxiliary spindles, with tachometers to measure spindle speeds. Independent electronic drives control the main and auxiliary tables, whose speeds are measured electronically. Controls are in a separate console. The orbiting turntable is driven by a timing belt from the motor located near the spindle center.

Electrical Features

Twenty-four slip rings provide electrical connections between specimens on the table and external equipment. Three power rings are rated at 15 amps



Slip rings, brush assemblies



Schaevitz' Type DC-4

220v, the others at 50 amps 220v. Eight of the instrument rings power and monitor the auxiliary drive; four are on the auxiliary spindle.

Rings are bronze, faced with approximately 1/16" of coin silver. Brushes are a special silver graphite combination for proper wear relationship between ring and brush and minimum extraneous electrical noise. Each ring has three easily removed brushes to maintain even contact. Insulation has been selected for optimum arc resistance, dimensional stability and strength under humidity and temperature variations.

An electrical counter in the control console indicates speed, and switching permits monitoring either the main or auxiliary spindle. Speed ratios are so selected that 600 voltage pulses are produced per revolution of the main spindle and 60 of the auxiliary spindle, making it possible to observe both speeds with appropriate accuracy.

Other Detail

Range of steady acceleration, 0-100 g. Range of sinusoidal frequencies, 0-30 rps. Peak to peak travel (radial displacement of satellite turntable relative to main spindle, 12 in. Controls, power on-off switch, 2 to 10-turn helical potentiometers, pilot lights for "power on" and "motor on" for each spindle.

Speed measurement, RPM pickup with 4-decade electronic counter on spindles, gate times of 1/10th, 1 and 10-seconds. Accuracy, ±1 count, representing 1/600 or 1/60 of a revolution/gate time. Rated load, satellite turntable—2½ lbs, main table—5 lbs. (at each of two stations). Power supply source, 220 or 440 v., 60 cycles, single or 3-phase, 3 kw. Test stand, size—36x 40x54", weight, 1200 lbs.

HIGH-INTENSITY .3 MICROSECOND SPARK LIGHT

Type **LS-020, by Avco Research and Advanced Development Division,** freezes motion for advanced missile design or environmental study. Four models provide light bursts from .3 to 1 usec., with the size of the point light varying from .015 to .060 inch diameter depending on energy levels from 2 to 20 joules. The spark pulse, from the discharge of a coaxial capacitor in an air gap, may be synchronized with a Kerr cell shutter r used to trigger other devices. The light source is housed in a cylinder which also acts as an rf shield 12½"x5" in diameter. Price $900, delivery 30-60 days.

For More Information
Circle EQ RSC #1

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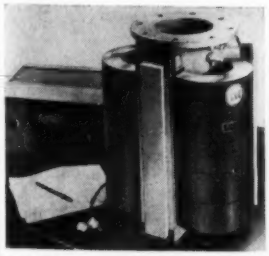
LARGE ION PUMP FOR ULTRA-HIGH VACUUMS



PDV-300 DriVac by Consolidated Vacuum Corporation is an electronic getterion pump with three-electrode construction for higher speeds and elimination of pressure surges when operating against inert gases. Nominal pumping speed is 300 liter/sec. Ultimate pressure is $2x10^{-10}$ mm Hg—the lowest reading obtainable on a commercial ionization gauge as determined by the X-ray limit of the tube. Stainless steel casing withstands bakeout temps to 450° C. Sputter cathode has expected life of 200,000 hours were pump operated at set pressure of $1x10^{-7}$ mm Hg, and much longer at lower pressures. Applications include semiconductor and vacuum tube processing, electron microscopes, particles accelerators and field emission studies.

For More Information
Circle EQ RSC #2

* * *

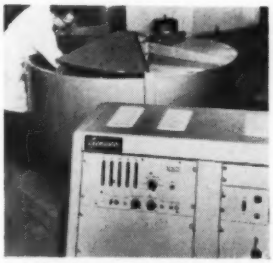
DOUBLE INTEGRATING VIBRATION METER

by Unholtz-Dickie Corp. provides standardized simultaneous output signals of displacement, velocity and acceleration from any piezoelectric accelerometer. Sensitivity can be set to give one volt per inch displacement and one volt per g acceleration on Dial-A-Gain instruments or the forces read directly on the internal meter. Velocity signal is standardized to 96.4 mv in/sec. Said to be especially useful in calibrating accelerometers and velocity pickups. The dialing of sensitivity allows direct comparison with standard transducer.

For More Information
Circle EQ RSC #3

* * *

FAST RESPONSE CENTRIFUGES



by Genisco, Inc., for production acceleration or laboratory testing. **Model 1220** subjects a 150-lb., 18" cube test specimen from 0 to 250 gs at 24" nominal radius; **Model 1230** tests a 150-lb. 24" cube to loadings up to 200 gs at 42" nominal radius. Max centrifugal capacity of both is 15,000 g-pounds. Welded steel tubs limited to approximately 42" height for accessibility to specimen. Modular construction and overhead mounted accessories permit later addition of optional features, including program and servo controls, digital speed indicators, temp chambers, tv viewing systems and slip rings. Aluminum rotating arms are constant within .5%, as is repeatability. Boom speed of Model 1230 is infinitely variable to 600 rpm, that of the Model 1230 to 400 rpm, measured by direct-reading tachometer.

For More Information
Circle EQ RSC #4

* * *

PORTABLE VIBRATION EXCITER

by Gulton Industries, Inc., permits quick field calibration of vibration pickups. The compact eight-pound unit, operates directly from a 110v 60cps power line and has a simple, reliable amplitude indicator. Claimed accuracy is within 5 per cent at the power supply frequency. Calibration point, 10g peak (other points available on order). Price, $850, in a wood carrying case 9½x8½x7" high weighing 8 lbs.

For More Information
Circle EQ RSC #5

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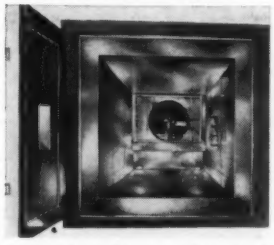
ALL-WELDED, STAINLESS STEEL WALK-IN CHAMBER



by American Research Corp. assures that no moisture from high humidity tests can infiltrate the installation. Chamber produces —100° to +300° F temperatures, relative humidities from 20 to 95 per cent, and altitudes to 100,000 feet. Oversized air mover keeps temperature gradients to an absolute minimum.

For More Information
Circle EQ RSC #6

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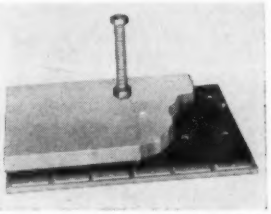
VIBRATION ISOLATING MACHINERY MOUNT



Series HM, by Barry Wright Corporation, withstands loads from 8 to 64 tons per mount. Designed for exceptionally-heavy high-capacity mechanical and hydraulic presses of 200-ton capacity and above, the series has 12 basic sizes constructed of individual Type 297 Barry isolators secured between common base and top plates. The neoprene isolating medium is available in various stiffnesses.

For More Information
Circle EQ RSC #7

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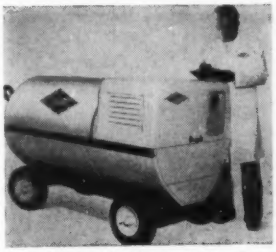
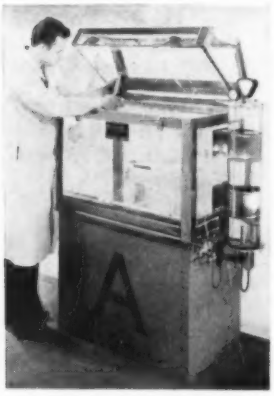
PORTABLE LOW-TEMP DEMONSTRATION UNIT



by General Dynamics Corporation maintains CO_2 at 300 psig 0° F by a self-contained refrigeration unit operating from standard 110v. The unit, known as the Liquiflow Portable, has 1,000-lb. capacity and is easily moved anywhere in a plant for demonstration or tests on four heavy-duty rubber wheels. Either low pressure liquid CO_2 or CO_2 vapor can be used in it.

For More Information
Circle EQ RSC #8

CORROSION-RESISTANT, ALL-LUCITE CHAMBERS



by **Associated Testing Laboratories, Inc.,** in three sizes, are designed to reproduce salt fog effects. Similar to ATL's 20" cube Model SS-2-5, the new chambers are 24x24x24" **(SS-2-8)**, 24x 24x30" **(SS-2-10)** and 30x30 x30" **(SS-2-16)**. All four models meet mil specs and provide complete visibility of test specimens from all angles because of the all-lucite construction. Only two connections are needed, low pressure air and 115v AC. Temperatures controllers and indicators are included for both chamber and saturation tower. Prices range from $1,140 to $1,860.

For More Information
Circle EQ RSC #9

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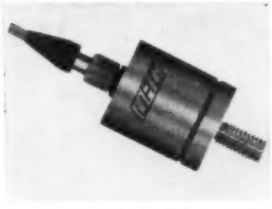
HIGH-G, LOW CROSS-SENSITIVITY ACCELEROMETER



Model 101, by United Aerotronics Corp., combines high sensitivity of 20 mv/g with cross sensitivities of 1.5%, 3% or 5 % as desired. Linearity is within 2% from 1 to 15 kc, and unit is said to measure up to 10^4 G in an environment from —65° to +365° F. Mountings are insulated and the connector hermetically sealed. The hardened steel case machined from solid stock has a sensitivity of less than 2%. Weight is 1.6 oz.

For More Information
Circle EQ RSC #10

HIGH VACUUM GATE VALVES

by **Consolidated Vacuum Corporation** have large, unrestricted (nominal 2, 4 and 6-inch) openings, said to be as much as 178 per cent more than other valves, to insure greater conductance. They are designed to mate with CVC oil diffusion pumps and others without curbing rated pumping speeds. Valve bodies are vacuum-cast as a single unit from aluminum, permitting operating pressures down to 10^{-6} mm Hg. The valve operator may be removed for cleaning or maintenance through a gasketed end plate without disrupting the line or system.

For More Information
Circle EQ RSC #11

* * *

COMPLEX WAVE VIBRATION EXCITER

by **Rototest Laboratories, Inc.,** under an exclusive Convair license, supplies wide band motion to payloads up to 120 lbs. without requiring complicated controls or monitoring systems. Designed for rapid checkout of production line items, it has a single switch and automatic shutoff to allow operation by unskilled personnel. Noise is said to be negligible. Known as the **Rotocon,** it meets acceptance test requirements for the Titan B program. Price, $3,850.

For More Information
Circle EQ RSC #12

* * *

HIGHLY SELECTIVE WAVE ANALYZER

Model OR-WA/1 by Gulton Industries performs spectral analysis of random or periodic vibration signals. It features ultra-sharp cutoff low-pass filters with zero center frequency rather than high center frequency band pass filters. The low-pass filter output can be fed to either a linear or square-law detector. Frequency response claimed is from 25,000 cps down to .2 cps. Overall amplitude accuracy is ±1 per cent of reading.

For More Information
Circle EQ RSC #13

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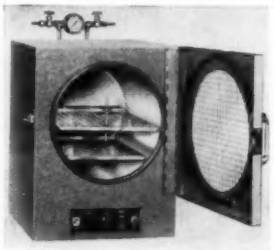
HIGH TEMP VACUUM OVEN WITH BIG DOOR



by **Labline, Inc.,** permits testing components from ambient to 500° F under vacuum. Radiant heating elements completely enclosed within the 11" diameter x12" deep stainless steel chambers, heat from room to 500° F in one hour with ±1° accuracy at all settings. An 11" diameter safety glass window, screened as an added protection, gives full view of contents. The glass is heat-treated to withstand 400° F thermal shock and 30,000 pounds psi. Overall size 18"x17"x 18" deep; price, $395.

For More Information
Circle EQ RSC #14

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MICROMETORITE DETECTION SYSTEMS FOR SPACE STUDY

by **Acton Laboratories, Inc.,** offer acoustical, electrical, film puncture and optical means of determining the numbers, size and damage capabilities of meteor dust particles. The acoustical system depends upon the impact of a micrometeorite on an exposed surface of rocket or satellite, the wave pulse being amplified and transmitted to the ground or stored in a memory circuit. The crystal microphone system can measure down to 2 micron particles, requires 140 mw, weighs 1 pound and occupies 27 cu. in. A second system depends on the voltage change caused by a micrometeorite breaking a strand of 20-micron wire triply wound around a form. Power requirements are negligible, weight ½ pound, volume, 24 cu. in. A thin film technique measures hole size during flight, while an optical method responds to the light produced when any small particle strikes a solid at high velocity.

For More Information
Circle EQ RSC #15

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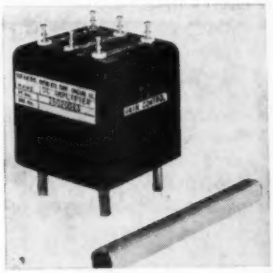
DC AMPLIFIER FOR TEMP OR PRESSURE CONTROLLING



by **Vap-Air Division of Vapor Heating Corp.** is compact, completely static and can be used with either temp or pressure pickup or potentiometer. Adjustable parameters permit use as a relay driver to provide essentially bi-stable action. In this configuration, a relay can be energized with a signal voltage change of 1 millivolt.

For More Information
Circle EQ RSC #16

* * *

NEW ENVIRONMENTAL CABINET SERIES

Testonic, by Blue M Electric Co., is said to offer ex-

treme reliability at competitive prices. Four sizes are available ranging from stainless steel interiors of 20"x18"x20" high to 48"x24"x36". All are equipped with a saturable power reactor control said to eliminate the wear, burn or arc disadvantages of controls or switches. Compressor-condenser constant-flow system gives extra large capacity for rapid pull-down rate and extremely close temp control required for electronic parts or equipment testing. Adjustable velocity control to 250 fpm. Lead-in ports, double-glass door panel and terminals for multiple electrical connections are optional.

For More Information Circle EQ RSC #17

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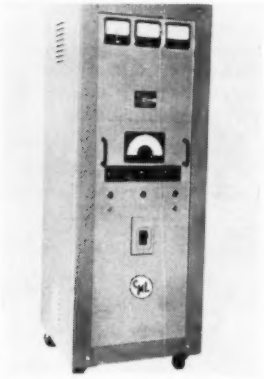
HIGH-POWER AC GENERATOR



Model M 1435D, by Communication Measurements Laboratory, Inc., provides precisely regulated voltage up to 2,000 va and a broad frequency range of 50 to 20,000 cps. Voltage regulation claimed is ±1%, stability ±.25%, distortion less than 1%, and frequency stability ±.001%. Weighing 1,050 lbs, the generator can be integrated into two or three-phase electrical systems and is encased in a mobile cabinet 66x27x26" deep.

For More Information Circle EQ RSC #18

* * *

DIFFERENTIAL TRANSFORMER, PRESSURE TRANSDUCER SERIES

by **Gulton Industries, Inc.,** are designed mainly for −65° to +450° F operation. At 2,000 cps, the **Glennite PX** transformers have nominal output of 40 mv/v input; that of the **PR** variable reluctance transducers is 15 mv/v input. Two diaphragms available for each of seven ranges from 0-15 to 0-500 psig: Ni Span C type, with excellent temp characteristics, suitable for most applications 17-7PH stainless steel for corrosive media. Types in both series measure only 3.22" max, with 1.535" max diameters, and will take 35 g shock for 11 ms.

For More Information Circle EQ RSC #19

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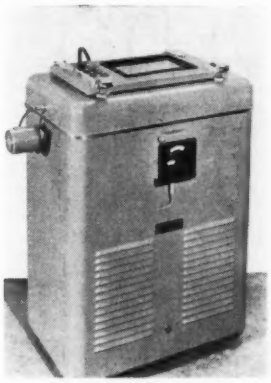
TOP-OPENING COMPACT CHAMBER



Model A-120-2-HC by Cincinnati Sub Zero Products, requires only 4½ square feet of floor space. Internally illuminated test area is 24"x12"x13½" and range is −150° to +300° F (±2°). Unit is caster-mounted and has two 2" access ports and a frost-free multipane window in the top-opening door.

For More Information Circle EQ RSC #20

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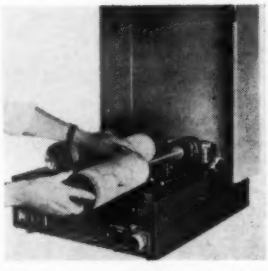
AUTOMATIC CURVE FOLLOWER FOR REPETITIVE FUNCTION VARIATIONS



Model FGE 5048 by Research, Inc., interprets function curves drawn with ordinary pencil on common graph paper. A servo-driven capacitive probe follows the pencilled chart revolving on a drum, and adjusts a potentiometer geared to it so as to divide any impressed voltage in the same proportion as the drawn curve divides the graph scale. Intended for guiding automated processes and programming analog computers and controllers, the device can be obtained with two and three channels synchronized. Drum rotation time is adjustable from 300 sec. to 10 sec. per revolution.

For More Information Circle EQ RSC #21

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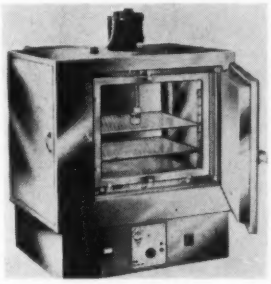
COMBINATION TEMP. HUMIDITY CHAMBERS



by **Blue M Electric Co.** for ASTM and similar cement and corrosion tests operate at 90-99% rel hum from room temp to +85° C. For temps below seasonably high ambient, tap water is circulated through baffle cooling coil. Power-O-Matic 60 Saturable Reactor system, without contacts, switches, moving parts or auxiliary mechanisms give straight-line control and infinitely proportional wattage control. Overtemperature protection is standard. Cabinets have polished stainless steel interiors and exteriors. Four standard sizes, with interiors ranging from 14x13x14" high to 37x19x25" high. Air volume adjustable, 0-30 changes per min. Low velocity air is convected vertically across cooling coil before entering chamber. Cabinets come with two expanded stainless shelves, glass thermometer and hygrometer, line cord and plug.

For More Information Circle EQ RSC #22

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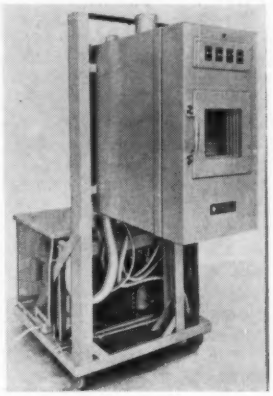
SPECIALIZED TEST CHAMBER



Model SU-120-1-HCR, by Cincinnati Sub Zero Products, is designed for use with standard tensile test equipment. The self-contained chamber can be hydraulically raised or lowered for different levels of operation. Range is −120° to +300° F and test area is 22"x7"x8" deep. Two one-inch access ports and a frost-free multipane window are provided. Unit is caster-mounted.

For More Information Circle EQ RSC #23

DU-O-PANE®

Manufacturers of windows for

ENVIRONMENTAL TEST CHAMBERS

- Temperature Range −180° F. to +600° F.
- Special applications up to 1000° F.
- For vacuum and non-vacuum installations

WE DESIGN TO MEET YOUR REQUIREMENTS

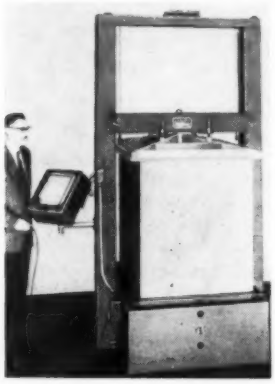
Large stock of Tempered, Pyrex, Vycor and Safety Glasses insures quicker deliveries

NATIONAL DU-O-PANE CORP.

EST. 1916

21-23 Grattan St., Brooklyn 6, N. Y. HYacinth 7-5050

COMPRESSION MACHINE FOR PACKAGING TESTS



by **L.A.B. Corporation** features an integral recorder which automatically plots pressure and deflection on a graph chart for a permanent record. Three compression ratings are available: 2,000, 5,000, or 10,000 lbs., and three height load openings: 48", 60", or 72". Maximum test specimen weights for three compression ratings are 700, 1,200 and 4,700 lbs. respectively. Accuracy claimed is ±1% of full scale.

For More Information
Circle EQ RSC #24

PORTABLE COMPACT CATHODE FOLLOWER

by **United Aerotronics Corporation** has a self-contained regulated power supply, weighs only 9 pounds and measures 10½"x5½"x2¾". Input impedance is 1,000 megohms with frequency response of 1 cps to 500 kc ±1%. Gain is .98 and noise level said to be less than 20 x 10^{-6} volts. The instrument has a built-in test signal and 10 watts at 110v.

For More Information
Circle EQ RSC #25

* * *

SUBMINIATURE ACCELEROMETER

Model AA-1220 by Gulton Industries, Inc., is said to broaden the useful frequency measurement spectrum by over 25 per cent. Weighing only 4 grams, it has a resonant frequency of 125 kc, providing a useful range to 25 kc, and can measure accelerations to 15,000 gs. Special design minimizes dc shift in both axes and a tranverse response of less than 3 per cent is claimed. Housed in titanium and priced at $265, it is .87" long overall and .45" diameter.

For More Information
Circle EQ RSC #26

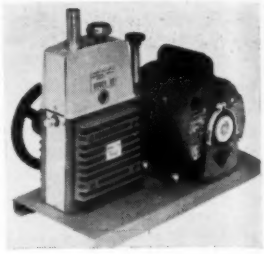
* * *

WATER COOLED SHELL HIGH VACUUM OVENS

by **Tri Metal Works** are said to operate continuously at any temp range between 0-500° and 0-800° C, with uniformity in the work zone of ±3°. Radiant heaters and reflective shielding heat a suspended muffle, which is said to achieve excellent control and fast heat-up and cool-down. Several vacuum pumping systems are available, with 1x10^{-6} mm Hg attainable. Ovens come in 8x8x14" and 14x14x16" interiors, with provision for six thermocouples.

For More Information
Circle EQ RSC #27

HIGH SPEED SINGLE STAGE VACUUM PUMP



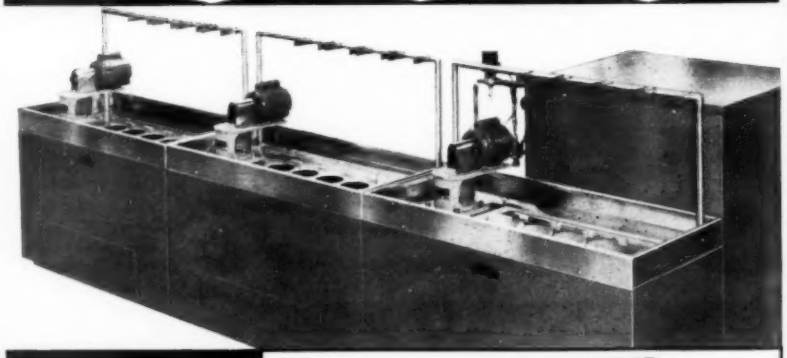
Cenco Hyvac S14 by Central Scientific Co., is oil sealed and rated at 140 liters per minute at atmospheric pressure. Utilizing the internal vane principle with a gas ballast, it will pump down to a guaranteed pressure of 10 microns of mercury. Metered amount of lubricating oil enters the pump through an oil hole in the housing, reducing wear to a minimum and providing a seal between intake and exhaust ports. The stage is not completely submerged in oil, reducing oil requirements. With 115/230 v, 60-cycle motor sells for $225.

For More Information
Circle EQ RSC #28

PRECISION 3-ZONE MASS PRODUCTION LIQUID TEMPERATURE CALIBRATION BATHS +150°C. to −85°C.

For precision temperature calibration on a mass production basis. Three separate agitated liquid baths. Fast recovery after loading. Complete recovery in 10 minutes with 1,000 BTU thermal load. Stainless steel cabinet tops contoured at rear to drain off oil drippings from fixtures hung on drying racks. Open rolled edges on top wall prevent liquids from creeping beyond top. Temperature variation in each bath less than 1°C. ± .1°C. point control (repeatability, speed of response, and on-off differential). Each chamber, 5 cu. ft.

TEMP. RANGE	HOT +150° to +50°C.	MEDIUM +50° to +20°C.	COLD −20° to −85°C.
CAPACITY	6,000 BTU/hr.	1,000 BTU/hr.	6,000 BTU/hr.



HARRIS REFRIGERATION CO.

312 RIVER ST., CAMBRIDGE 39, MASS.
Member Environmental Equipment Institute
Refrigeration experts since 1934. Environmental testing equipment for every requirement, standard or custom models. Write for our advice. No obligation.

BENCH-TYPE 3-ZONE SMALL BATHS

Each bath 4" dia. x 4" deep, same temperature range as large unit. Hot, +150° to +50°C.; medium, +50° to +20°C.; cold, −20° to −85°C. ± 1°C. control.

Literature for Environment

Avco Corporation, Wilmington, Mass., has a four-page, green and white leaflet on its SM-005 shock test machine which can easily be used for production testing of electronic and electro-mechancial components up to 30 pounds. Designed to produce a variety of shock pulses to meet mil specs, it can also deliver square, triangular and sawtooth pulses. Velocities from 15 gs to 3000 gs are obtainable. High repeatability is a feature. **(Circle EQ RSC #38.)**

* * *

Consolidated Vacuum Corp., Rochester, N. Y., has a handsomely illustrated two-color booklet on its stainless steel vacuum jacketed transfer lines for low temperature liquid oxidizer fuels for rockets and missiles. The booklet points out 89 per cent of fuel can be lost in transfer from storage areas to launching site. **(Circle EQ RSC #39.)**

* * *

Barry Wright Corporation, Watertown, Mass., describes its heavy duty mount, Series HM, capable of supporting loads to 128,000 pounds, in a two-color bulletin punched for ring binding. The series covers 12 basic sizes, each in four different load ratings. The bulletin includes technical data on isolation of shock and vibration of mechanical and hydraulic presses of 200-ton capacity and greater. **(Circle EQ RSC #40.)** A similar bulletin details the new Serva-Levl mount, Series AM, for high-precision machine tool support. This mount, designed for loads up to 30,000 pounds, uses a column of air to achieve isolation from vibration while maintaining a claimed absolute level within .00005 inch per foot. **(Circle EQ RSC #41.)** Barry also has a data sheet on its All-Angl isolator, Series B64, which protects and isolates electronic equipment from shock, vibration and steady-state accelerations encountered in high-performance aircraft and missiles. **(Circle EQ RSC #42.)** Barry's Horizontal-Force mount, Series RM, is described in another bulletin. This mount is said to handle 4,000 pounds and isolates predominantly horizontal shock and vibration forces. **Circle EQ RSC #43.)**

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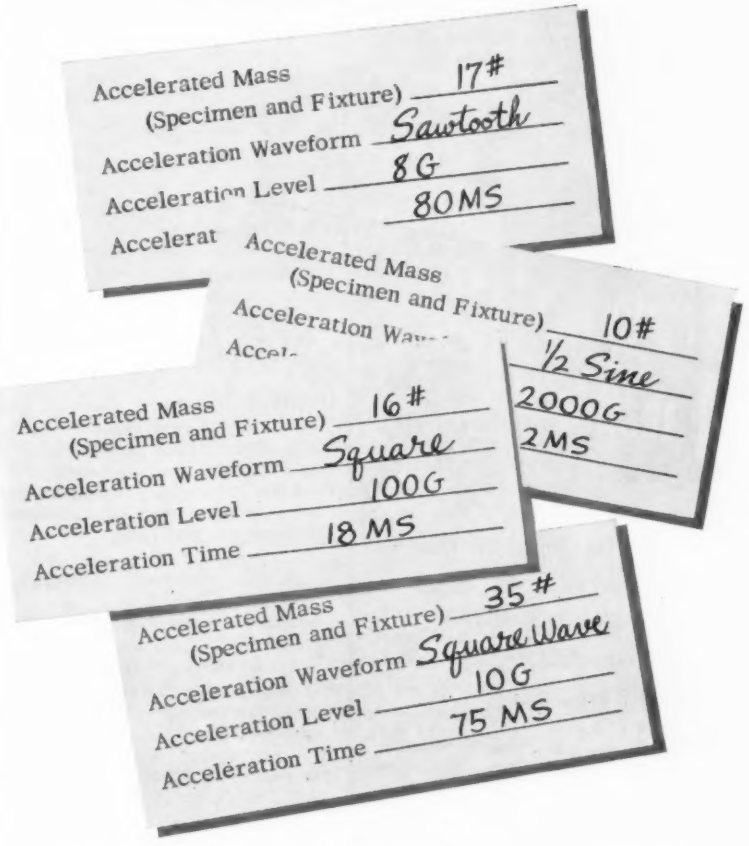
Cincinnati Sub-Zero Products, Cincinnati, Ohio, offers an illustrated folder on its small capacity hi-low temperature chambers. The 1 to 10 cubic foot units have —150° to +300° F. ranges and are intended

Shock Tests only HYGE can perform reliably... repeat reliably



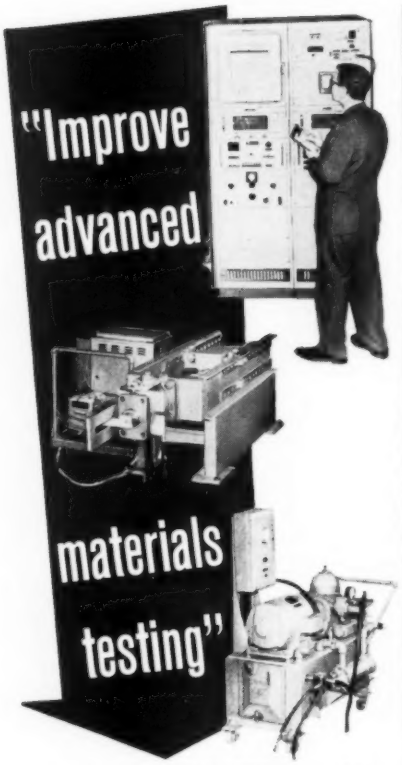
11 MS ½ sine, 6 MS sawtooth, 10 MS square . . . these are typical shock pulses frequently encountered in today's military specifications and routinely tested with CVC HYGE. Military specs also call for many special shock waveforms which have been accurately performed and repeated only with HYGE. A few of these are shown above.

Choose from 3 HYGE models . . . laboratory or production line . . . with thrust capacities up to 40,000 lbs. force . . . and acceleration to 2000 G. Each features HYGE's unique adaptability to the widest range of shock tests, to meet your present and *future* shock test needs.

Write for HYGE Bulletins, or outline your requirements and we'll make a recommendation.

Consolidated Vacuum Corporation

ROCHESTER 3, NEW YORK



CompuDyne's DYNATEST* machine loads 50,000 pounds at 20 cps and can follow a programmed heating rate of 200°F/sec. to 3000°F simultaneously

Now you can get dynamic response characteristics well beyond the capabilities of conventional test machines by using DYNATEST Model DTM-3. The new machine meets demands created by rapid technological developments in nuclear, aeronautical, space vehicle and propulsion fields.

The Dynatest machine features a high-speed DYNAJACK* electrohydraulic ram arranged to program force and strain applied to the specimen. Continuous cyclical force or strain versus time may be employed with manual or full automatic programming. Temperature programming is accomplished by close coupled resistance heating or combinations of resistive inductive or radiant heating. Temperature is detected with a low mass thermocouple welded to the specimen.

Special environmental testing is greatly simplified because the Dynajack hydraulic load cylinder, load cell, and extensometer are easy to remove and can be placed in special jigs if necessary.

Complete specifications and details are in Data Sheet S-101. Write for your copy today.

**Tradename*

CompuDyne Corporation
400 South Warminster Road
Hatboro, Pennsylvania

for lab and job shop applications. **(Circle EQ RSC #44.)**

Lord Manufacturing Company, Erie, Pa., has an illustrated 8-page guide to its resilient mountings and mounting systems. Design considerations and application and performance data for 23 product series are included. **(Circle EQ RSC #45.)**

* * *

MB Electronics, New Haven, has a new 16-page brochure describing its line of products to excite, measure and control vibration. Sections on the principles of vibration testing, pickups and meters are included. **(Circle EQ RSC #46.)**

* * *

Associated Testing Laboratories, Inc., Wayne, N. J., has issued an illustrated bulletin describing its new line of all-lucite salt spray chambers for environmental testing. The chambers meet corrosion test requirements of MIL-E-5272C, MIL-S-19500B, Par. 40.9, and other military and commercial specifications. **(Circle EQ RSC #47.)**

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Unholtz-Dickie Corp., Hamden, Conn., has issued a comprehensive bulletin describing specs, typical uses and construction features of its new double integrating vibration meter with unique Dial-A-Gain features. **(Circle EQ RSC #48.)**

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Columbia Research Laboratories, Woodlyne, Pa., has a short form product bulletin describing its miniature, solid state amplifiers for use with piezoelectric accelerometers in missile and airborne shock and vibration studies. **(Circle EQ RSC #49.)**

* * *

International Testing Laboratories, Inc., Newark, N. J., describes its metallurgical, wet chemical, plastic, spectrographic, engineering and environmental test facilities in a colorful brochure. **(Circle EQ RSC #50.)**

Government Publications

Almost daily the U. S. Department of Commerce releases a number of technical reports for use by industry. These documents are sold through the department's Office of Technical Services, Washington 25, D. C. Here are some recent releases and their prices:

(ONR—Office of Naval Research)
(WADC—Wright Air Development Center)

A Bibliography on Acoustic Sources and Their Related Fields, by G. B. Thurston and R. Stern, Willow Run Laboratories, Univ. of Mich., for ONR. Material dating back to 1935 on single sources and receivers, arrays of sources and receivers, transducer properties and acoustic fields. 68 pages. Order No. PB 161330 $1.75

Cryogenic Data Book, by D. B. Chelton and D. B. Mann, National Bureau of Standards Cryogenic Engineering Lab for WADC. Physics of eight liquefied gases and more than 40 solids at extreme low temperatures are illustrated in graph form. 155 pages. Order No. PB 151837, $3.

Steady State Undamped Vibrations of a Class of Nonlinear Discrete Systems, by P. R. Sethna, B. E. Fristedt and V. G. Harvester, Univ. of Minn., for WACD. The vibration of structural elements subjected to periodic loading either acoustic or otherwise was studied. Special effects of the ratios of the linear natural frequencies on the qualitative nature of the solutions are demonstrated. Solutions for some specific problems were found and results checked against those from an analog type computer. 37 pages. Order No. PB 161129, $1.

The Thermal Conductivity of Solids at High Temperatures—a Bibliography, by W. T. K. Johnson, Diamond Ordnance Fuze Laboratories, U. S. Army. Lists 308 publications since 1940 with abstracts, and refers to 166 papers before 1940. Emphasis on measurement techniques. 72 pages. Order No. PB 161118, $2.

Short Time Human Tolerance to Sinusoidal Vibrations, by G. H. Ziegenruecker and E. B. Magid, Aero Medical Lab, WADC. Vibratory flight environment such as would be encountered in launching and re-entry of manned space vehicles was simulated on a mechanical shake table. Volunteers could stop the low frequency vibrations (1 to 15 cps) when they reached tolerance limits. 18 pages. Order No. PB161083, 50c.

Damping Energy Dissipation at Support Interfaces of Square Plates, by T. J. Mentel and C.C.Fu, Univ. of Minn., for WADC. Study of acoustic fatigue resulted in a preliminary design curve permitting rapid evaluation of structural and material parameters to produce maximum interface damping. 29 pages. Order No. PB 151972, 75 cents.

Qualitative Aspects of Fatigue of Materials, by H. N. Cummings, of Curtiss-Wright Corp., for WADC. Study of why some metal parts and structures have a much shorter useful life than others. Variables affecting the fatigue of metals are discussed and theories on the mechanism of failure reviewed. 263 pages. Order No. PB 161145, $4.

Investigation of Fatigue Properties at Room Temperature of High-Strength Steels Having High Tempering Temperatures, by H. N. Cummings, of Curtiss-Wright Corp., for WADC. A statistical investigation of fatigue characteristics, particularly of missiles and other flight vehicles. Emphasis on testing materials of higher strength-to-weight ratios designed for high operating temperatures. 105 pages. Order No. PB 161144, $2.50.

An EQ Special Report:

Progress in Nondestructive Testing

(This summary of progress in another testing discipline covers developments during the past five years. It is based on a report for the Third International Conference on Nondestructive Testing held in Tokyo last March, and is reprinted, with permission, from "Nondestructive Testing," the official journal of the Society for Nondestructive Testing.)

by Raymond A. Pulk

Detroit Arsenal
Centerline, Mich.

IN THE AREA OF RESEARCH and engineering development, progress can be noted in the considerable effort expended by government agencies and private industry. An increased funding outlay by the defense agencies in particular is reflected in basic and applied research programs in universities and by private contractors on isolation of material parameters which can be utilized in nondescructive testing methods. Increased attention in the effect of grain size and strain gradients on ultrasonic attenuation and signal response can be cited as an example of such work. In fluoroscopy, research is continuing on methods of increasing sharpness, resolution, brightness, and ultimate sensitivity of image formers.

The introduction and continuing research on image amplifiers and image intensifiers is introducing a new viewpoint in the usability of fluoroscopic techniques. In radiography, research has produced faster films of good sensitivity and contrast features. Portable low voltage radiographic equipment is continuously being developed as well as high voltage sources as the linear accelerator and electrostatic generator types. Equipment research is continuing in the field of eddy current, electromagnetic testing, and ultrasonics—much of this work being accomplished by the commercial sources themselves.

New Areas for X-Ray Work

New areas are being opened as a result of research in techniques and development of equipment for X-ray microscopy, projection micro-radiography, X-ray diffraction, and X-ray spectroscopy. Magnetic particle and penetrant methods—two of the original reliables in nondestructive testing, are constantly obtaining refinements, principally as a result of commercial research. Finally, at least two large government agencies are presently conducting research on infrared scanning techniques as a means of material inspection.

Initial basic and applied research of the past has been chiefly responsible for the increased impetus of industrial applications utilizing non-destructive test methods. This, of course, is reflected in the high quality standards necessary in the aircraft, missile, and atomic energy industries. Within these years increased use has been made of high energy X-ray sources such as the betatron, electrostatic generator, and the comparative newcomer—linear accelerator.

Conversely, increased employment of isotopes such as Iridium 192, and Cobalt 60 in lieu of radium can be cited. Constant refinement of lower voltage generators coupled with issuance and improvement of radiographic standards and methods by such groups as ASTM Committee E-7, has led to a general growth in intelligent use of this tool as a means of quality control.

The high demands of aircraft, missile, and atomic energy components have pressed into service the techniques of eddy currents, ultrasonics, and magnetics. These tools, however, are finding increased application in the so-called domestic product industry. A continuous ultrasonic scanning unit for steel strip in an automotive plant can be cited as an example. It is well to note the growing tendency to assert nondestructive testing at as basic a point as possible in the production of the component. This is a philosophy which has obtained impetus in the last few years, as an outgrowth of the recognition that nondestructive testing has most economical potentiality when applied to the raw material.

Increasing emphasis has been placed on the idea of adequate education and training of personnel engaged in nondestructive testing. Such activities are accomplished by schools, government agencies, industries, and the technical societies themselves. Besides the educational program in the semi-annual meetings of the National Society for Nondestructive Testing, the number of educational sessions, schools, courses, and symposia sponsored by the individual sections has markedly increased. On a more formal level, academic and practical study courses are being offered by some high schools and at least two colleges.

Industry Training Personnel

Commercial sources and industry in general have been playing no small role in training of personnel. Equipment manufacturers such as Magnaflux, General Electric, Sperry, Westinghouse, Picker, Branson, Curtiss-Wright, can be noted amongst many others. The Atomic Energy Commission has been oustanding in formulating and directing complete courses in use and handling of radioisotopes. Although training has vastly increased, there is still a conviction that education at the university and technical school level could be expanded.

The sense of importance of the field of nondestructive testing is noted by the increase in membership of the Society for Nondestructive Testing and the accelerated interest and efforts of such groups as E-7 of ASTM and special nondestructive testing committees within other societies. The responsibility of the field to the general economy has led to establishment of the Technical Council of the Society for Nondestructive Testing to provide technical service to industry. Under the guidance of Richard H. Lambert, the council has been substantially staffed by national experts in industry and in the application of methods.

An idea of the increased amount of exchange of information in this field is reflected certainly in the growth of sections of the national society and the increased number of local meetings. No less than ten national and regional meetings have convened since 1955 in addition to allocation of nondestructive testing sessions on the programs of other societies.

International Exchange

An awareness of the maturity of this field has been paralleled by strengthening of the feeling that much is to be gained by exchanges of knowledge and ideas on an international basis. Such exchange has increased as a result of activities of the International Relations Committee of the National Society and its consequent promotion of personal working relationships between co-workers and colleagues in the United States and other countries.

ENVIRONMENTAL BUSINESS...

Tenney Acquires West Coast Base In Los Angeles

Tenney Engineering, Inc., of Union, N.J., one of the oldest and largest manufacturers of environmental test equipment, is expanding to the West coast.

Saul S. Schiffman, chairman of the board, announced that Tenney has contracted to acquire Harvick Manufacturing Corp. and Harvick Machine Corp., of South Gate, Calif., and will produce environmental simulators there. South Gate is a section of Los Angeles.

The two companies, combined into one Tenney subsidiary under the name of Harvick Manufacturing Corp., will also continue to design and manufacture missile and airplane handling equipment, Mr. Schiffman said. The subsidiary is expected to add $1 million to Tenney's sales in the first year.

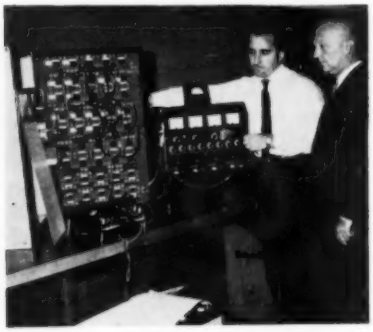
Second Recent Acquisition

It is Tenney's second acquisition in six months. Last summer the company acquired Communication Measurements Laboratory, Inc., of Plainfield, N. J., a pioneer manufacturer of electronic generators and instruments for space systems and scientific and industrial quality testing.

Mr. Schiffman described the Harvick step, an all-stock transaction, as "a long-awaited move to sustain our growth and bring us closer to the heart of our important Western market."

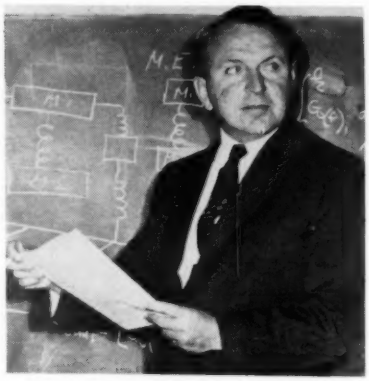
He added that Harvick would continue with the same personnel, although its staff would be enlarged and its scope of operations broadened. The companies have produced for the Nike, Hercules and Honest John missiles and for the B-52 and B-58 programs. They have also manufactured material handling trucks, trailer chassis, flanging machines, field office engineering trailers and other equipment for both military and commercial aviation.

Thermo Analyzer



W. J. Holman, of Vapor Heating Corp.'s Vap-Air division, Chicago, demonstrates the passive analog computer he developed to J. E. Morris, the firm's New York City district manager. The device cuts the time it used to take to design of Vap-Air's cooling effect detectors—including prototype models and wind tunnel tests—to a day and a half. (For more info circle EQ RSC F.)

Moves Up at Textron



George H. Mettler during a blackboard session with his sales engineers while he was president of MB Electronics division of Textron Electronics, Inc.

Charles D. Brown Named Head of MB Electronics

Charles D. Brown, a General Electric Co. executive, was named president of MB Electronics, New Haven manufacturer of vibration test systems, amplifiers and jet engine parts. He succeeds George H. Mettler, who has been elected a vice president of Textron Inc., parent company of Textron Electronics, Inc., of which MB is a division.

Mr. Brown, a 1937 graduate of Northwestern University, was most recently marketing manager of GE's Instrument department, with headquarters at Lynn, Mass. Previously he was with the company's Light Military Electronics and Heavy Military Electronics departments in marketing and sales capacities.

Tenney Sets Up Ground, Flight Support Division

Simultaneously with the Harvick announcement, Tenney Engineering disclosed organization of a special division to design and manufacture ground and flight support equipment. Monroe Seligman, president of the company, said the division would specialize in servo, hydraulic, pneumatic and electrical test stands and launching devices and containers.

The new division, based in Union, has already received orders for test stands from a prime space engine contractor and two major commercial airlines, he said, adding:

"This is a natural extension of our capabilities in the environmental and electronic fields.

ALI Changes Name, But Testing Service Is Still Acton Labs

Acton Laboratories, Inc., Acton, Mass., has changed its corporate name to Technology Instrument Corporation of Acton, according to an announcement by Leroy C. Bower, general manager.

Effective last Dec. 1, the change "will simplify marketing of the diversified product lines, consisting of measurement and control instrumentation, rocket, missile and satellite instrumentation and systems, and communications equipment," Mr. Bower said.

The firm's testing service retains the Acton name, however. It is now known as The Acton Laboratories of Technology Instrument Corporation of Acton.

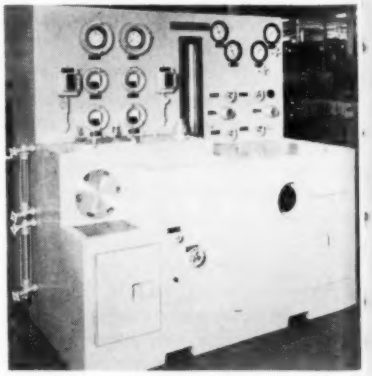
A wholly-owned subsidiary of Technology Instrument Corporation, ALI has also been known for years for its instruments in the fields of phase measurement, delay measuring sets and radio.

Auto-Control Laboratories Completes Expansion Move

Auto-Control Laboratories, Inc., designers and manufacturers of environmental and other test equipment and facilities, has moved from Inglewood, Calif., to larger quarters at 5251 West Imperial Highway, Los Angeles.

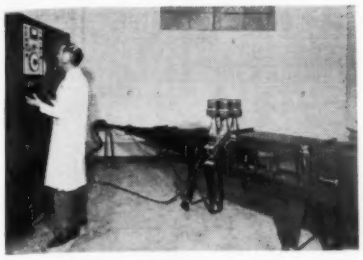
Concurrent with the move, Joseph T. Abdo, president, announced this executive roster: Kelly P. Abdo, secretary-treasurer; Robert L. Lieberman, assistant general manager and chief engineer; Charles R. Knokey, vice president and chief of environmental department; John M. Buchwitz, sales manager, and Wallace Jones, shop superintendent.

Testing for UAL



Explosion proof test bench designed and built by The Rucker Company, Oakland, Calif., especially for United Air Lines, simulates actual flight conditions for precision testing of fuel booster, feeder and transfer pumps of DC-8 jets. A feature is adaptability to variations in scroll configurations of pumps permitting changeover without loss of time. (For more info circle EQ RSC J.)

American Laboratories In 15,000' Expansion



This acoustic test facility is among a number of new installations recently announced by American Laboratories division, Fullerton, Calif. It is said to have 10 times the acoustic power and double the cross-sectional area previously available. (For more info circle EQ RSC G.)

American Laboratories division of American Electronics, Inc., has opened 15,000 square feet of additional test space adjacent to its Fullerton, Calif., buildings.

Among other things, the expansion included setting up an acoustic test lab and a jolt and jumble environmental unit which brought from William H. Grumet, general manager, the claim that the division offers one of the most complete testing services on the West coast for pyrotechnic and ordnance devices.

Acoustic equipment includes Ling-Altec's Model 12185 calibrator and Model 21BR180-1 microphone system for monitoring and analysis of test conditions.

Controlled Environment Produces 'White' Rooms

Formation of Controlled Environment, Inc., of Needham, Mass., to design and install "white rooms" has been announced by Walter W. Kenyon, chairman, and Robert D. Peck, president, of the new concern.

The officials said Controlled Environment will not only supply super-clean enclosed areas for manufacturing, assembling and testing high precision products but will also train personnel in the procedures necessary for working effectively in them. *(For more information circle EQ RSC L.)*

CompuDyne Wins $372,000 NASA Contract for Langley

CompuDyne Corporation, Hatboro, Pa., has been awarded a $372,000 NASA contract for an integrated group of four control systems to be installed at Langley Research Center. The systems will control the operation of the high pressure combustion unit and main tunnel ejector of the eight-foot high temperature structures tunnel there.

The company supplied a pressure control system for the large blowdown wind tunnel placed in operation by the English Electric Co., Ltd., at Preston, England. As with the NASA contract, the work included an analog computer study. *(For more information circle EQ RSC I.)*

Du-O-Pane Glass Withstands 1,000°

National Du-O-Pane Corporation, Brooklyn, N. Y., has announced successful application of new type environmental observations windows that withstand temperatures up to 1,000° F. Special glass of this type has been installed at Custom Scientific Instrument Co., Kearny, N. J.

Other new glass types for both vacuum and non-vacuum purposes are available in two temperature ranges: —180° to +350° F and —180° to +600° F. The firms also stocks a variety of common sizes and thicknesses of tempered safety and other glasses.

Du-O-Pane also is offering a fast repair service for restoring defective or broken observation windows of any brand. *(For more information circle EQ RSC K.)*

Field Sales Managers Picked

A new field sales organization for products of its 11 divisions has been established by Gulton Industries, Inc., Metuchen, N. J. Sales managers named for the company's three prime market areas are: Jerome G. Friedman, systems; James A. Pitrelli, industrial, and Frank R. Meshowski, components. All report to F. Robert Walker, marketing manager.

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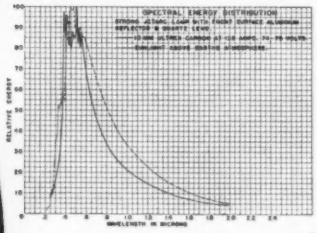
Strong SOLAR RADIATION SIMULATOR

The Strong blown type Jetarc, the most powerful carbon arc, has proved to be the best artificial simulator of solar energy in the development and testing of space vehicle components.

Useful radiation is efficiently collected by first surface reflectors and concentrated at the reimaging point from where it can be projected by a quartz objective system in a pattern shaped to fit the work area. A circular radiation pattern totals 374 watts with an 80% uniformity of field or a total of 668 watts with a 60% uniformity of field. Higher or lower energy unit areas, can be obtained by variation in optics or projection distance. Large areas can be covered by multiple employment of lamps using either superimposed or overlapping pattern technique. Other, less powerful carbon arc sources, are also available for smaller work areas.



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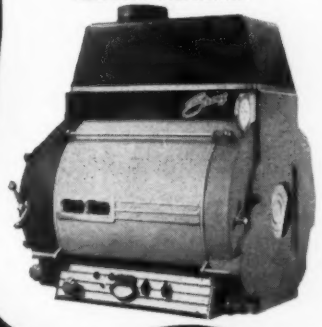
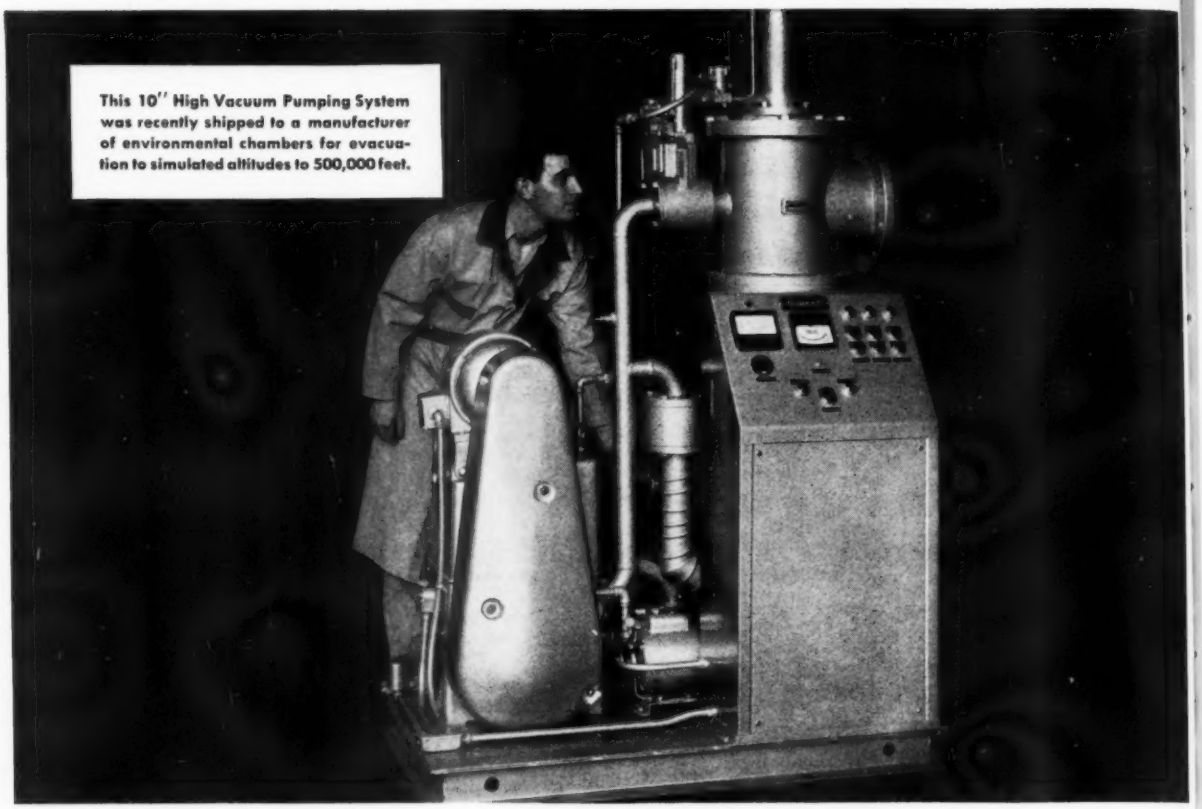
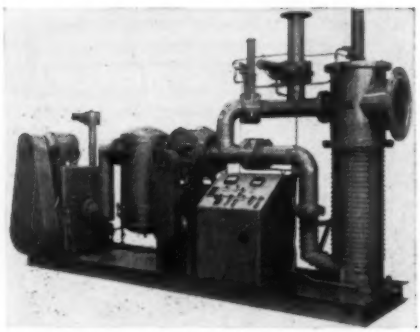




This 10" High Vacuum Pumping System was recently shipped to a manufacturer of environmental chambers for evacuation to simulated altitudes to 500,000 feet.

SAVE DESIGN MANPOWER AND CUT COSTS WITH STOKES HIGH VACUUM PUMPING SYSTEMS



Designed to evacuate an aerodynamic wind tunnel facility, this specially designed unit features 3 stages: mechanical pump, Roots type blower and 16" diffusion pump. System is base plate mounted and includes a graphic control panel. The unit is one example of Stokes ability to meet out-of-the-ordinary system requirements.

Now, your valuable engineering time can be saved for direction to other phases of your project. Stokes solves the vacuum portion of your problem with completely packaged pumping systems. Whether your test needs are 150,000 feet or 1,500,000 feet of simulated altitude, and test volume requirements are 10 cu. ft. or 10,000 cu. ft., Stokes has the system to do an effective and efficient pumping job.

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Vacuum Equipment Division

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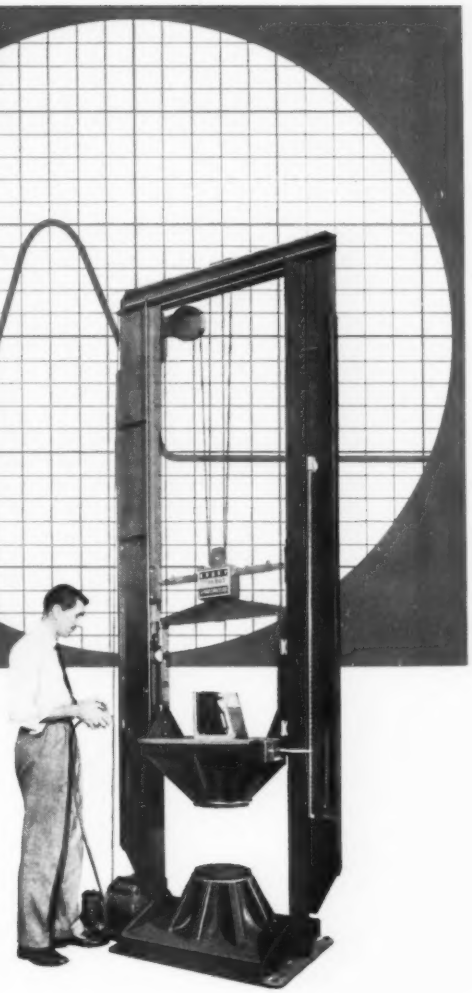

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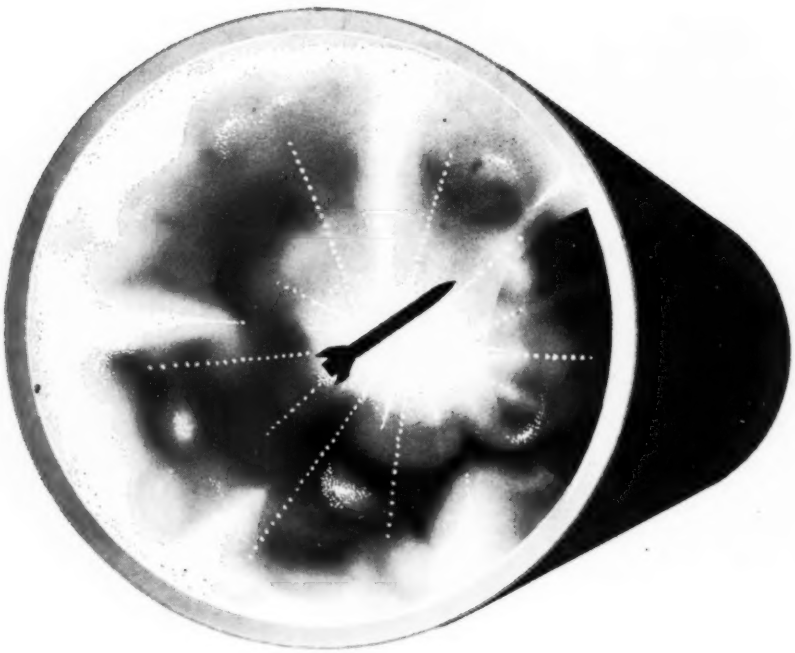

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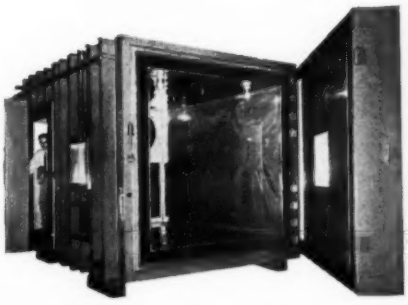

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